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The magazine *for*, *by*, and *about* telescope makers!

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TELESCOPE MAKING

The magazine *for*, *by* and *about* telescope makers!

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Cover: Kevin Hotten (r), Jack Roach (c), and Alan Otterson (l) of the Kalamazoo Astronomical Society stand behind Hotten and Roach's 10″ f/6 mounting that exploits "Dobson" plastic on plastic-bearing technology for its sturdiness and smooth motion.

Editorial

Innovation: what a crazy thing it is.

Sometimes I find myself wondering: amazed, amused, hard put to believe what TM's readers have come up with since we started publishing four years ago. When we published Bob Kestner's article, it seemed to me that a "Dobsonian Revolution" would run its course, with the net result of a few hundred large telescopes in the hands of experienced amateur astronomers.

But it didn't happen that way. Everybody went and built Dobsonians, rank beginners included. It kicked off an aperture revolution that still leaves people like me, who grew up thinking of a 12″ as HUGE, kicking and screaming in bloody mental protest, "It's too big." I love it.

Now we've begun to see Dobsonian "technology" influence areas of telescope design that have nothing to do with Dobsonian telescopes. For one thing, at this year's Riverside and Stellafane, the old-time pipe equatorial was quite notably absent. Nobody's the least bit sad to see the amateur classic German pipe mounting go the way of the dinosaur — they were awful. Many people who might have built them a few years ago took the alt-azimuth route instead. But — the big surprize — the *equatorials* shown this year were some of the best I've seen. Suddenly, inspired by the "buttery" feel of Teflon on PVC, people have applied new methods to equatorials. "Who'd a'thunk" that Dobsonians would improve the equatorial!

How? Two ways: increased pride coupled to greater demands on performance from those who built them, and the new technology. In talking to people, I sensed a new attitude toward

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equatorials — they're being seen as a *specialized* mounting for photography and photometry instead of the be-all and end-all. When someone builds an equatorial now, he puts more effort into it because, at the very least, it has to be as solid as a well-made Dobsonian would be. So there they were: solid one-arm forks, massive conic polar axes, and heavy duty German equatorials. If they're not going to perform right, why bother?

Then there are those innovators exploiting the plastic-on-plastic bearing "teknik." I was one of them, and though I could not show my telescope at either meeting, I did write it up for the RTMC-82 Proceedings. At Stellafane and again at AstroFest, Kevin Hotten and Jack Roach showed a breakthrough instrument with concrete-filled PVC pipe riding on Teflon pads. I thought it was a flaky idea for about 30 seconds — then realized that these guys have something that's really exciting. So I confidently expect that we're in for a round of improvements on amateur equatorials.

Well, I thought the equatorial platform was done, too. I certainly didn't see how the Poncet platform could be improved, so Graeme White's bending pier dropped out of the clear blue sky — both a pleasure and a surprise. Then came the nested-corner equatorial platform, and in this issue, Bob Barclay's improved version that needs no electricity. I'd use it by giving the hydraulic cylinder a pump or two each time I swung the telescope to a new object and then letting it quietly leak down as I observed. What nobody can predict is what will come next — but I now expect and fearlessly predict further innovation.

Where is this all taking us? I talked to a lot of people this year, trying to plumb attitudes and ideas that haven't surfaced quite yet. One thing that I noted was a strong desire for crisper star images. People are willing to pay an awful lot for sharp, wide-field eyepieces, and a premium price for really good mirrors. But there also seem to be more refractors showing up. Several years ago I looked through one at Riverside and decided that I had to get off my tail and build a telescope around a lens I'd acquired, quite by chance, some years earlier.

This year I talked to Roland Christen at Stellafane about refractors, and looked through his current apochromat. Nice, very nice. If enough people *see* what a refractor can do, they will catch on again. The desire is there, and refractors provide those super images. Sure, they're expensive, but so is everything else these days, and the pleasure of using truly fine optics is there. Remer's refractor kits aren't too expensive, either. With a 6" refractor for fine definition and a 16" or bigger reflector for a light bucket, a serious observer could be pretty happy.

Well, that's just the tip of the innovation iceberg. Some times people fear innovation, and that's natural enough because innovation changes things. But as telescope builders, we have nothing to fear — we *are* the innovators.

Sincerely,

Richard Berry

Richard Berry
Editor

Letters

M. Poncet Writes . . .

Dear Richard / Thank you for the honor in TM#14!

Apart from honor, it is very interesting to see the interest of people. I have written to Dick Houskeeper because his tangent arm is by far the best arrangement for photography. See also what I write, and try to impress it on your friends when you see them since I cannot write to all of them. Porter's Palomar split ring is good if it's well made, but it necessitates equatorial orientation of the supporting arc and concentricity with the pivot, which is mechanically difficult.

Porter's Springfield mount (Newton axis on the eyepiece [ocular] is very clever, but you can make a stationary eyepiece telescope with the Poncet platform, too. The telescope is hung by the axis, using a cord (cabertom) for moving altitude, as did Ells in England for his rotating observatory. Best regards, and thank you again!

Adrien Poncet
39300 Crotenay
France

— In his letter to Dick Houskeeper, M. Poncet explains that he has tried using a lead screw with the nut embedded in rubber, and that this eliminates backlash effectively. He also mentions that a cable drive is also free of backlash but requires a motor with a slow rotation rate. He also adds: "Of course, you must think and keep smiling and never complicate, but simplify."

Digital DEC

Dear Mr. Berry / I, and I expect many other readers of TM, would be very interested in seeing an article on digitizing declination for an equatorial mount. I understand that one method might be through the use of a gear drive, an attached plate with a specific number of holes to produce light pulses, and photoelectric sensors feeding to a counting system that drives a digital readout.

48➤

an extremely portable 17½" dobsonian

I have constructed a very compact Dobsonian. Last winter, while I was traveling in California with a friend, I was lucky enough to get a set of 17.5" optics. Having the mirrors, I started the design of a Dobsonian at once. Due to the many inspiring articles in TM, I had plenty of ideas, and in my case, I needed to make the telescope as compact as possible for easy transport.

The back end box of the Dobsonian is only 22" x 22" x 15" and is made of marine-type plywood of ⅜" thickness. The back end of the box has cut corners to admit a somewhat lower mounting position in the rocker. The tailgate is conventionally made with a sling of stainless steel sheet metal and nine point flotation backing of the mirror. The three angular supports, which were cut out of marine plywood, rest on knurled nuts. The side bearings are stainless steel sheet metal running against Teflon pads, which results in the smooth and nice operation typical of Dobsonians.

Although closed tubes are often preferred, you can also achieve good results using open tubes if heat currents and stray light are not bothersome. My telescope uses aluminum tubes which make an open Serrurier-type structure which is very stiff. It is assembled easily with knurled knobs.

The rocker is made out of ½" marine plywood with double thickness near the side bearings. It has both a front and a back board for extra stability.

When designing a portable mounting, you should think primarily in terms of rigid design rather than simply having thick enough material. Cut down the dimensions of parts that otherwise would be subject to bending and torsion. Due to the small dimensions and rigid structure of the box and rocker, I was able to use thinner plywood than normally used for 17.5" Dobsonians, and the weight will then also decrease. The total weight of the telescope is 32 kg (72 lb) plus the 14 kg (30 lb) mirror.

The telescope folds down in a few minutes to a package of 24" x 24" x 30" and is ready for transport in any small vehicle. Few telescope makers of yesterday would have believed a truly portable, not just transportable, telescope of half meter aperture. Today it is made possible with Dobsonian thinking. It's certainly true that the sky is the limit!

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Sweden

■

An Equatorial Platform with a Hydraulic Escapement

For me, a telescope is only half a telescope if I can't take photographs through it. Nonetheless, I had purchased Coulter's 17.5" mirror and was building a Dobsonian telescope for it. Since I live on the edge of a city, I needed a portable equatorial platform that I could take out for observing — not too sophisticated or elaborate, but adequate to the task.

Richard Berry's article on equatorial platforms in the January 1982 issue of ASTRONOMY started me thinking. Graeme White's hinged box idea seemed to be a good starting point, but by flipping the upper box into the lower box, I realized I could save a lot of space. As an example of the way in which people's minds run along similar tracks, I had only just completed mine when I saw Chuck Olson's design in TM#15!

I began by making two 1:8 scale models before building and testing the real thing. I kept telling myself as I built the platform that it was the only obvious way to go about it and that it would be highly unlikely — or downright odd — if somebody else didn't think of it simultaneously.

There are slight differences: my platform starts at an angle and comes to rest horizontal, whereas in Olson's design the platform continues through the horizontal, coming to rest at the opposite angle. My design is also a bit more sturdy and a good deal smaller.

The question of what kind of drive to use on this type of platform must take into account the fact that the majority of the telescope's weight acts directly downward. There is no center point or point of balance with this kind of platform as there is with the Poncet, horseshoe, and similar designs — in fact, the off-center design begs one to use gravity as a drive, since gravity happens to be in plentiful supply. It is more accurate to describe the mechanism which controls the fall of the platform due to gravity as an escapement. If, on the other hand, the platform were oriented with the hinges on the west side (i.e., mirror imaged) then the platform would have to be driven against gravity, and the mechanism would be a drive. Everything is reversed for the southern hemisphere.

The hydraulic escapement principle seems to be the best way to go for a number of reasons. Aside from the fact that it requires no electricity, there are several sound mechanical reasons for not using a motor "drive." As previously mentioned, the weight of the telescope acts downward and the greater part of that weight would be brought to bear on the threaded rod and nut needed for the drive. Frictional forces would be very high, so an unusually powerful motor would be needed to overcome these. Gravity would provide no assistance here — the screw will drive, but it will not allow itself to be driven.

Furthermore, in order to disengage the drive, the system would require a split nut on the threaded rod, as is the common practice with Poncet mounts, so some method for lifting the whole telescope and platform before engaging the split nut would be needed. This could be a very inconvenient operation for one person on a dark night.

Alternatively, the motor (which had been acting as an escapement on the descent) could be reversed and speeded up to drive the platform up again to its starting position. The power requirement for driving the platform up would be about the same as would be required to "drive" it down because in both cases the motor is working against friction. Forced to choose between the this and the split nut method, I would use this method, though it would take quite a bit of engineering.

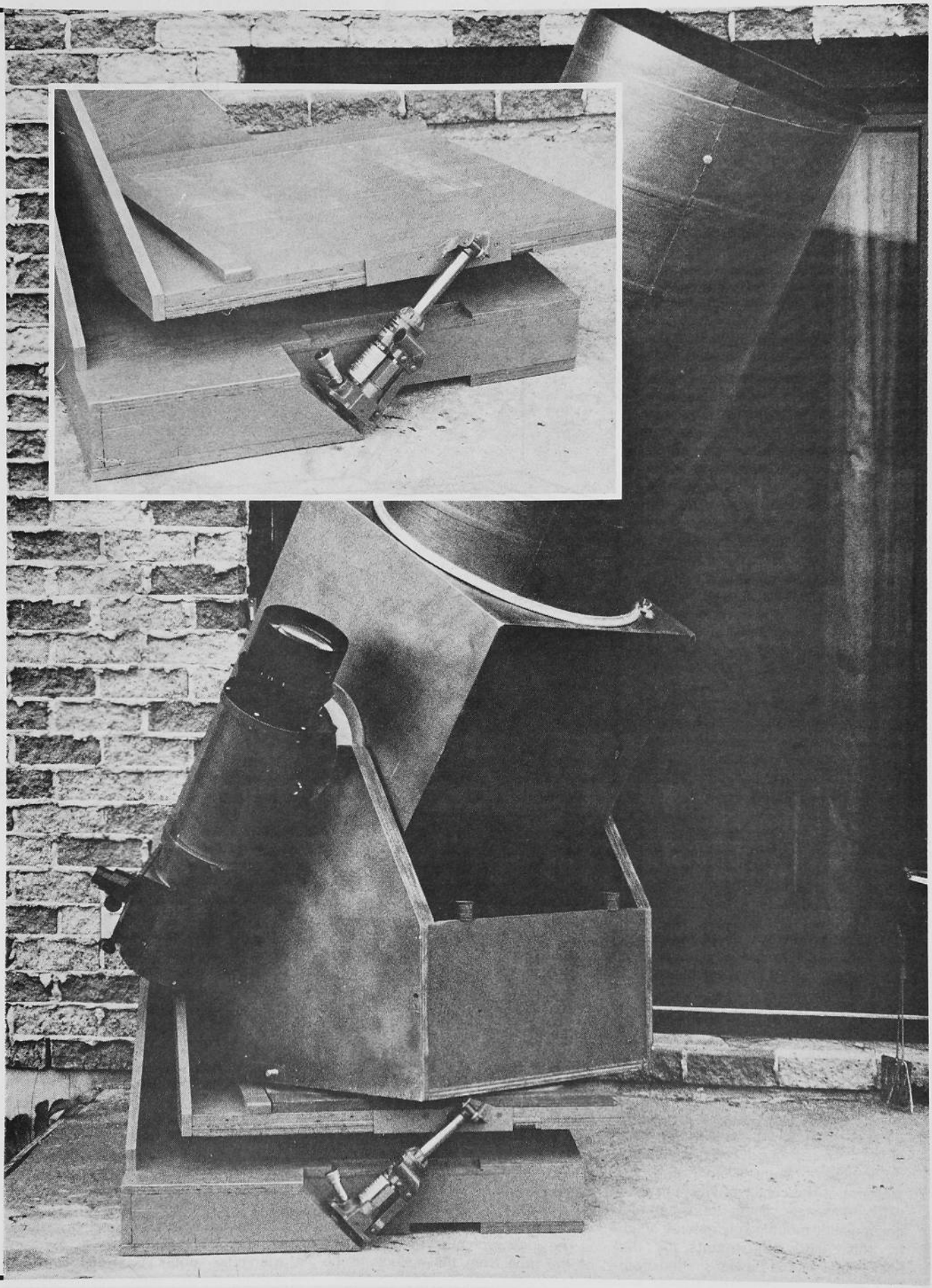
While I don't totally discount the use of an electric system with this kind of platform, mechanically it doesn't seem to be sound practice.

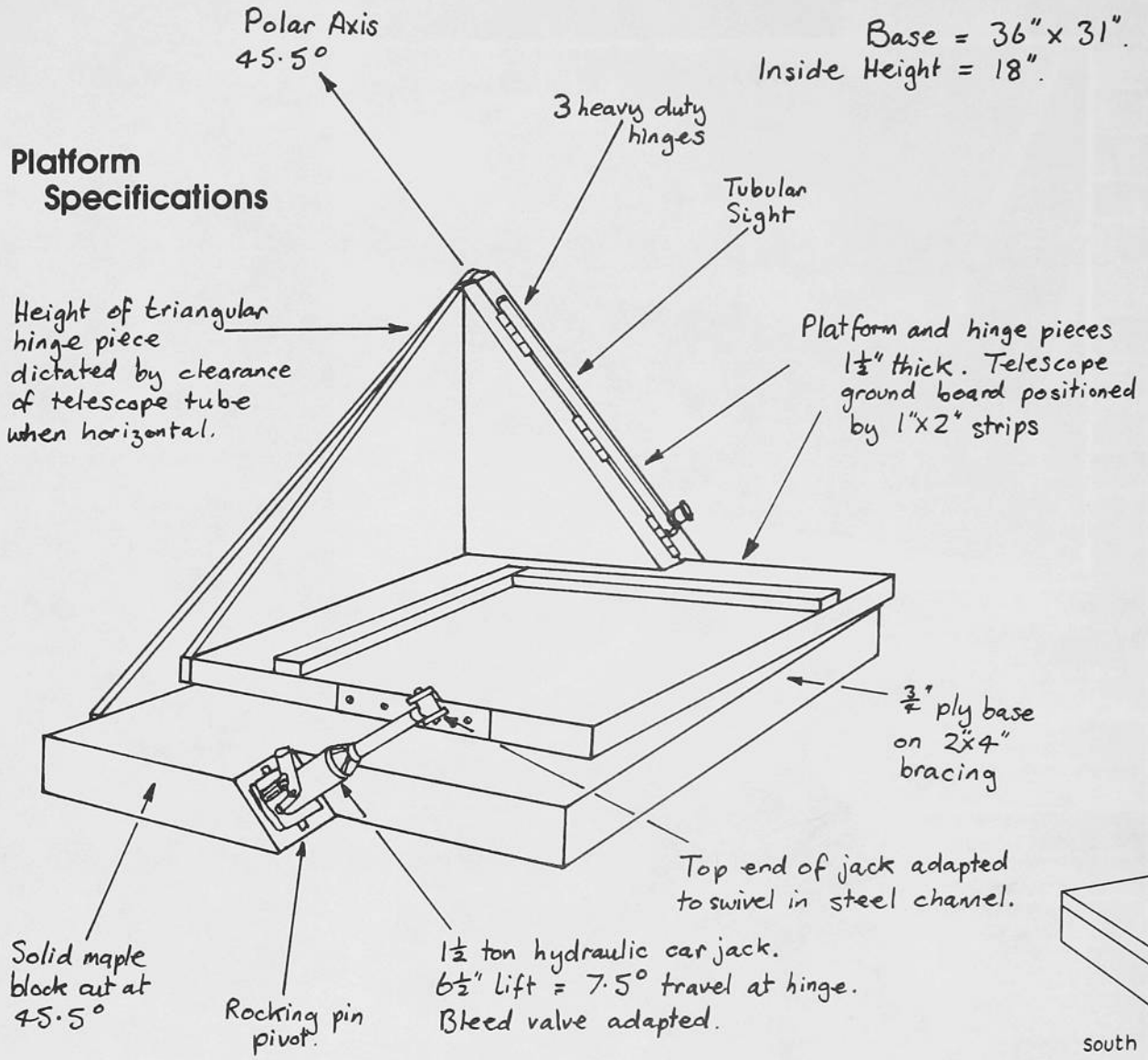
The hydraulic car jack provides a cheap, reliable and quite elegant way of raising the platform quickly and then slowly controlling its fall. The jack I use on this platform is the smallest size available: 1.5 tons with an extension of about 6.5". At the position I mounted it, this gives about half an hour of tracking time, although the last few minutes are quite unreliable. Mounting the jack closer to the hinges would, of course, increase tracking time but at the cost of inconvenient location and inadequate balancing of forces.

As it stands at the moment, my platform has, in effect, a three-point suspension system — the hinged section can be seen as the base of a triangle with the top of the jack as the third point at the apex, the telescope being cradled between. More powerful car jacks have a greater volume of fluid but not much more extension, so using a larger jack would not give increased tracking time, but would provide greater controlability due to the higher rate of flow of fluid through the needle valve. Furthermore, tilting the platform more than 10° risks toppling the telescope off to the east. Before this happened there would be another problem, though: as the mirror in the standard Dobsonian telescope hangs in a strap, tilting the scope to one side could cause stress on the mirror and slight loss of collimation. With the present design, then, half an hour of tracking seems to be the upper limit, but with a 17.5" f/4.5 optical system, that's an awful lot of photography!

A needle valve, the only part of the device that isn't available at the local hardware store, is simple to make if you have access to a lathe, or you can buy one. It replaces the ball valve installed in the jack body and gives surprisingly sensitive control.

I bolt the guide telescope onto either of the side bearings of the main scope and its eyepiece is very low, so no matter what position the telescope is in, I can reach the needle valve control knob. If reaching the valve were a problem, I could attach a flexible cable to it. The micrometer head on the needle valve provides a quick and reproducible approximation of the correct rate of descent which is, of course, dependent on the weight of the telescope, and observation through the guide scope provides fine control. I am not sure how much the viscosity of the hydraulic fluid changes with temperature — I hope I don't have to do spring and fall oil changes! By opening the needle valve wider, the telescope can be set to sweep





equatorially at whatever speed is convenient to the observer.

A disadvantage of this platform in its present state is that no declination adjustment during tracking is possible. As in all equatorial mounts, the declination axis should be at right-angles to right ascension. The only places where this prevails are at centers of the north and south sides of the ground board. If the ground board could be accurately tipped by pressure at either of these points, I would have a declination control of sorts. At the moment I am working on installing the cylinder from an automobile braking system into the platform at the center of its south side, with the master cylinder connected to a conveniently mounted micrometer head. In this way, adjustments to the micrometer would be transmitted from the master cylinder by the hydraulic line to the slave cylinder under the ground board. This is still very much in the design stage.

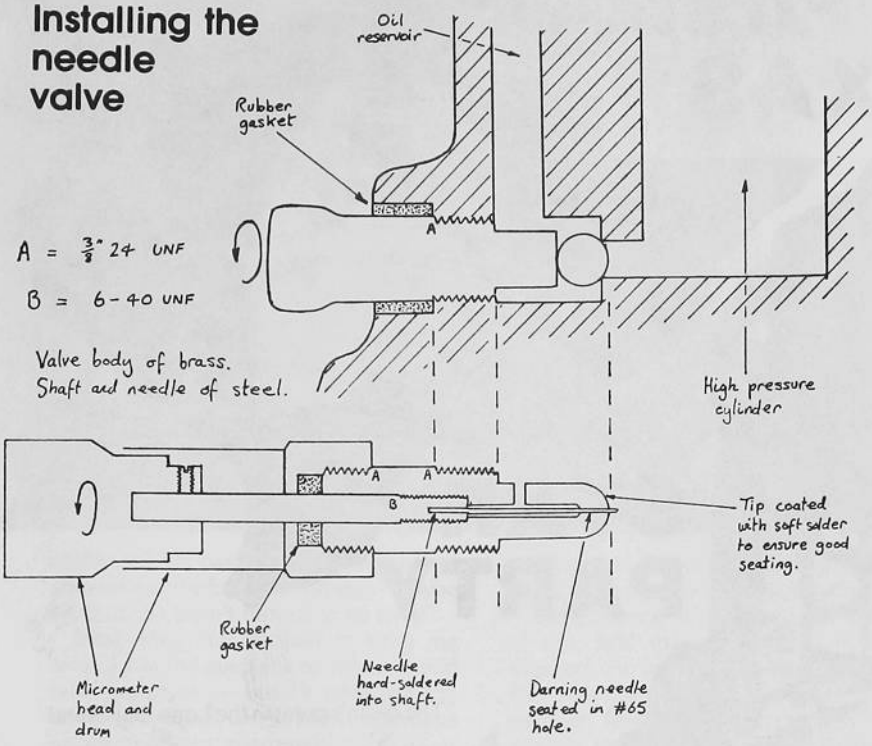
Polar alignment is comparatively easy with hinged box designs. The hinges are the most accessible part. My alignment system is very simple but it seems to work quite well. A piece of ¾" copper pipe is attached along the polar axis in contact with all three hinges. At the lower end of the pipe, a small diagonal mirror and an eyehole at the side let me look into it. At the top end there is a bored-out plastic insert which provides a slight constriction in the tube. The eyehole is only ⅛" in diameter, but with a little practice it's not difficult to center the eye on it accurately.

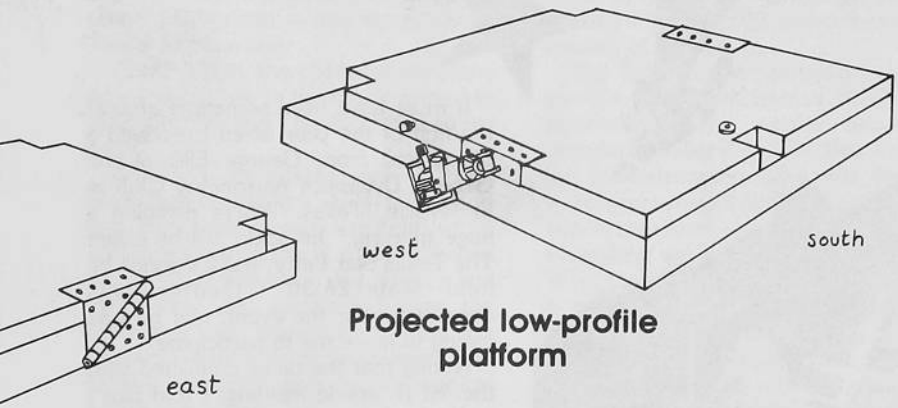
The angle subtended by the open end of the tube from the eyehole is 1.6°, adjusted by the internal bore of the plastic insert. The platform is first leveled using wood shims (leveling screws would be better), and then slid gently sideways viewing through the eyehole of the sight until Polaris just touches the edge of the tube on the opposite side of the Big Dipper. The polar axis is thereby pointed 0.8° away from Polaris at an elevation of 45.5°.

Although this method is obviously most efficient when Polaris lies either due east or due west of the celestial pole, it works at any time. If you're lucky enough to have a concrete pad to place the platform on, the adjusting device would not really be necessary. I am not so lucky.

Construction of the platform is simple. In the load-bearing areas, i.e., the triangular polar bearings and the

Installing the needle valve





Projected low-profile platform

platform itself, I doubled the ¾" plywood for extra strength and stiffness. The base is braced with pine 2 x 4s to provide enough height to avoid fouling the top of the jack when turning the rocker of the telescope. I don't know if it's really necessary to use the large wood block below the foot of the jack, but it seemed like a good idea at the time — certainly there's a lot of weight acting on it.

The top end of the jack fits into a pivot pin which must be accurately aligned at exactly the polar angle or it binds, causing the platform to drop in sharp jerks. At the bottom end a steel rod screws onto the base of the jack and this fits, in turn, into semi-circular slots machined into two steel plates attached to the wood block. In this manner, the jack pivots at its top end and rocks at its bottom end.

Although the sturdy construction makes the platform very heavy, it is surprisingly portable. I attached a pair of wheels which make handling a bit easier.

I would not want to make this platform any lighter for fear of compromising its rigidity, although bracing the joints with angle iron, as suggested by Chuck Olson, instead of double thickness plywood, might solve that problem. In fact if the whole thing were built from 1½" x 1½" angle iron, it would be lighter and just as strong — but it might vibrate like a tuning fork. It's something I want to try — perhaps the basis for a Mark II.

To sum up, the nested box design of platform with hydraulic escapement has the following advantages: 1) easy polar alignment due to accessibility of polar axis; 2) simple construction, with almost all parts easy to obtain; 3) no reliance on electrical supply; and 4) low cost — the whole unit, including the jack, cost less than $60.00.

There are three major disadvantages: 1) there is no fine adjustment for declination (at least not at the time of writing); 2) it requires a specially-made bleed valve; and 3) it is heavy, not ameliorated much by detachable wheels.

All three of the above disadvantages can be easily overcome if the evidence of the last five years of amateur telescope making is any guide. Big apertures are here to stay — but along with the big aperture goes the absolute necessity for portability, unless one is fortunate enough to live far from city lights. Conventional equatorial mounts are just not adequate for the task — and since large alt-azimuth telescopes seem to be the norm these days, we've got to get the bugs out of the platforms.

In the future, I hope, lies another promising development which I will describe here. As I have not made models or tested the idea yet, I can't tell how successful it will be, but by the time this article is printed, I will probably have one in operation. On the platform described in this article the polar axis is 24" long. On Chuck Olson's design it's even longer. There is no reason for it to be as long as this provided that it is sufficiently sturdy.

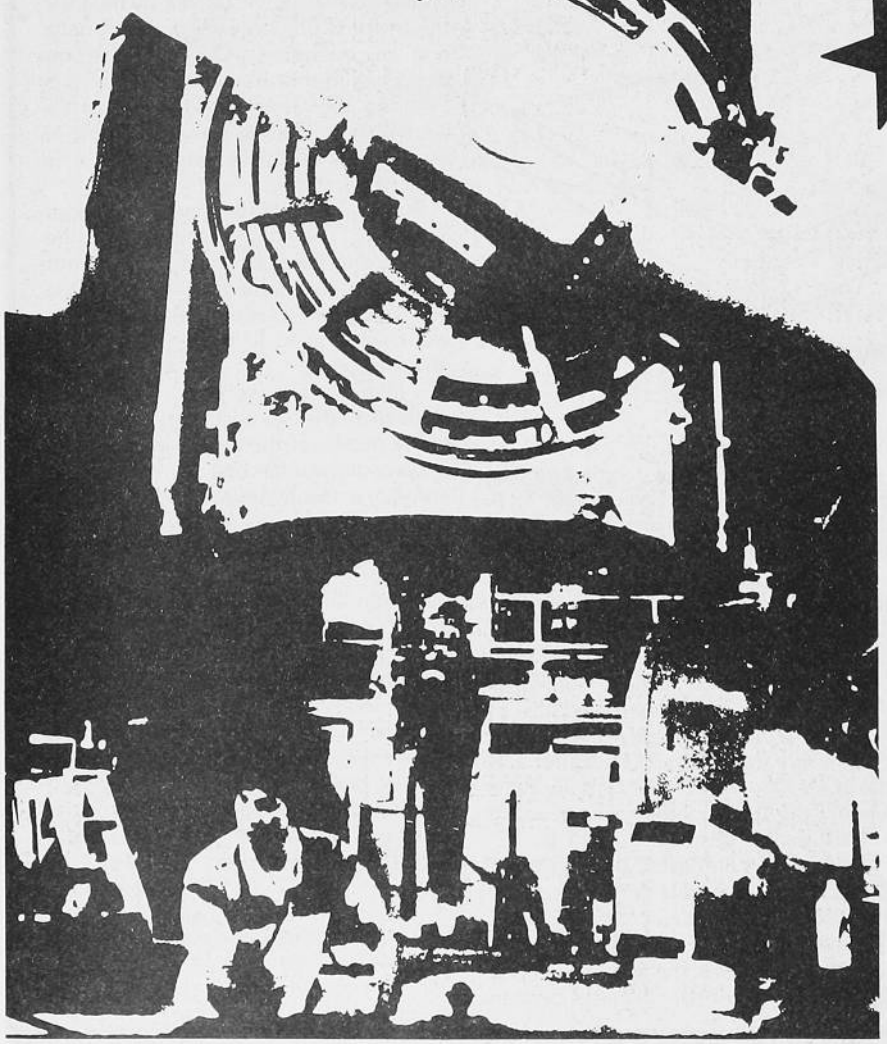
Suppose it could be made only about 8" long. The hinge could then be mounted at the polar angle in the center of the east side of the platform and hung below platform level. The whole platform would only need to be the size of the ground board.

I plan to cut squares out of the platform at the two northern corners and in the middle of the south side to locate the feet of the telescope's ground board, and place the hydraulic brake cylinder mentioned earlier just north of the single ground board foot. The platform would have to be sufficiently high so that at maximum tilt it would not hit the ground at its south-east corner.

A solidly built plywood platform would probably suffice, although metal might be more reliable. This design will give an extremely low profile platform, capable of carrying enormous weight, and should be very portable. If, in fact, the problem of constructing a sufficiently sturdy hinge can be solved, this design would make nested corner platforms obsolete.

Bob Barclay
3609 Downpatrick Road
Ottawa, Ontario K1V 9P4
Canada
■

The First TEXAS STAR PARTY



"The gazin's great in the Lone Star State!

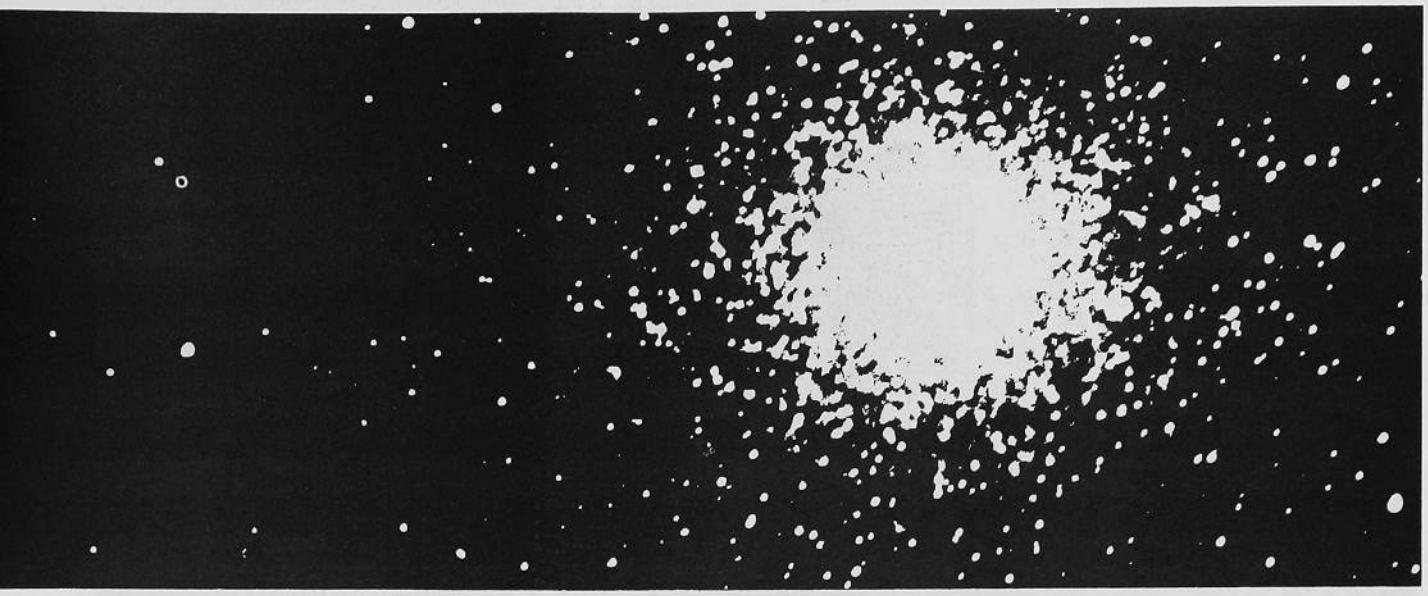
It must have been sometime around the first of the year when I received a phone call from George Ellis of the General Dynamics Astronomy Club in Ft. Worth, Texas. "We're planning a huge meeting," he said; "it'll be called The Texas Star Party, and it's gonna be held May 26-30." George was coordinator for the event, and he was calling to invite me to participate.

Noting that the dates conflicted with the '82 Riverside meeting, I told him I couldn't see how it would be possible to also include his meeting. He informed me that Richard Berry was planning to attend the first few days, then go on to Riverside, and I pointed out that *he* would be covering the meeting for *Telescope Making*.

Now started a Texas Blitz that made the battle of Britain pale to insignificance. Two and sometimes three days a week, I had calls from George. He really worked on me — until it reached the point where if I had a call at home in the evening, I automatically picked up the phone and said, "Hi George!".

Then Richard Berry realized that the Texas meeting also conflicted with the IAPPP meeting (at which he planned to give a paper), so when George offered to cover my expenses, I was hooked and agreed to attend.

Two things really decided me: I was curious whether George could really pull



continued to pass and I faintly heard someone in the background say, "Maybe he died; he hasn't moved in so long!"

Well, they literally had to drag me away from the eyepiece so others could take my place — but I'll never be the same again! Until you've seen the Omega cluster with an instrument of 17.5" or larger — with it a satisfactory distance above the horizon — you haven't lived. That's all I can say.

About 1 a.m. the effects of the plane ride and car trip to the ranch started to take their toll and I finally retired to my bed.

Knowing delegates would take advantage of the dark skies and stay up late, the meetings were arranged so no scheduled astronomical activities began before 12:30 p.m. each day. What a fine idea! The only exceptions were the workshop on telescope making on Thursday morning, the swap meet, and judging of instruments for mechanical excellence awards.

One thing can be said for Texans, they do things in a big way! All of the 32 presentations made during the four days were well-attended, both papers and workshop sessions, and everyone agreed that the mixture of amateur and professsional speakers was excellent. The professional speakers were the renowned Dr. Clyde Tombaugh, Dr. Bart Bok, Dr. Harlan Smith, Dr. Karl Henize, Dr. Reta Beebe, and Dr. Jack Marling.

Saturday evening was the "biggie." The hall was crowded as Dr. Clyde Tombaugh spoke about "Out of the Darkness — The Planet Pluto," describing how after searching thousands of plates and literally uncountable numbers of star images, the image that moved, Planet X, was found. When it was realized that Pluto's mass could not account for the disturbances on Neptune, he described how further studies were made with no success.

The patience of this man — a lifetime of star field examinations — is truly inspiring. An unexpected pleasure in the talk was the wonderful humor of the speaker; laughter was as prevalent as serious interest. The material can be found in his book, but the pleasure of hearing it live from the author beats any reading of a book.

The last speaker Saturday evening was Dr. Bart Bok, famous Milky Way astronomer who spoke on "Our Wonderful Milky Way." Dr. Bok is noted for his astronomy talks and for his wonderful sense of humor. This night he was in rare form — and with practically everything we learned about the Milky Way, there was a laugh to go along.
it off. A meeting of the size and complexity George described is no easy task even for a Texan. And also, by attending I could cover new and interesting developments on the telescope front for TM.

Thus it came to pass that on May 25 I boarded an American Airlines flight to Dallas, where George joined me in the final flight to Midland-Odessa. There a group from Dallas was waiting with a station wagon to drive us to Ft. Worth, some five hours away. The weather had been bad in the Midland-Odessa area, but as we went west, we drove through a sand dune area where it had been worse — the ground was white with hail. A lot had melted, but we estimated that originally some hailstones must have been the size of golf balls!

Weather, which had been bad in the Ft. Worth area for days before the meeting, was the prime topic of discussion during the drive. Good news had arrived just before our drivers had left — indications on radar maps on cable TV indicated clearing was about to take place. Fortunately, this was the case — we did have clear skies each evening even though atmospheric stability was poor.

Leave it to those Texans to do things right. The Texas Star Party is a star party above all else, and, gosh darn, they said, we aren't gonna let any lights interfere with the observin'.

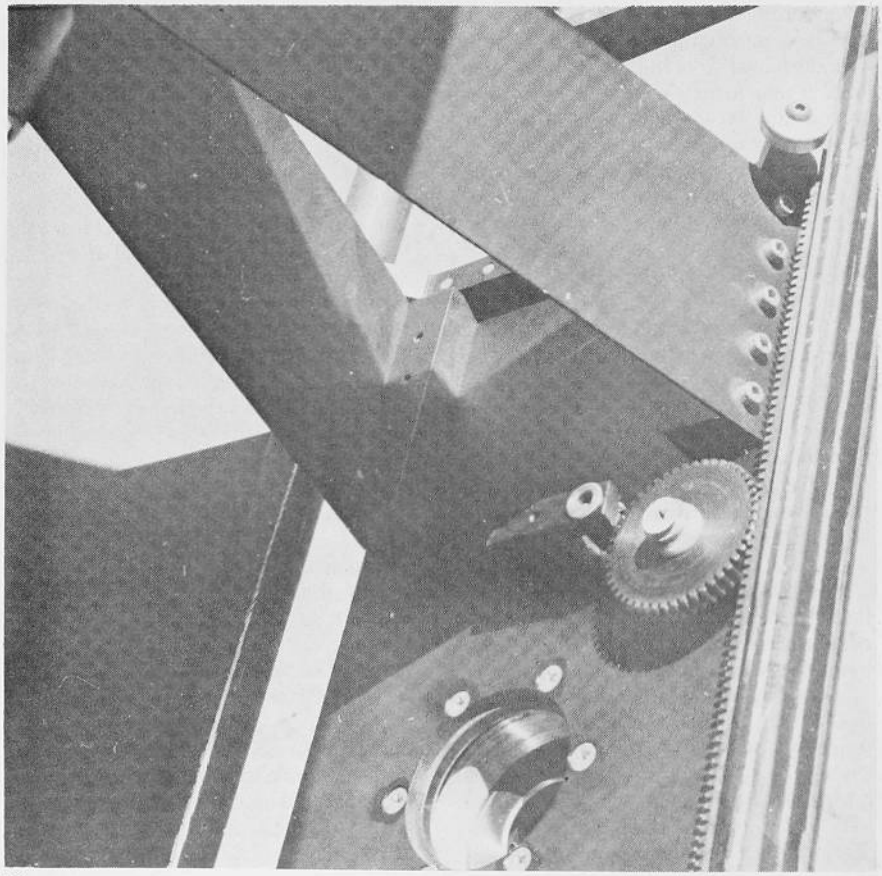
No car lights were allowed after darkness had fallen. All windows were blacked out on all buildings. All flashlights had to be fixed to only emit red light.

When we arrived at the Prude Ranch about 9:30 p.m., the blackout was already in full swing. I did manage to find my sleeping quarters and then wandered out with my red flashlight into the lower telescope field to see what early arrivals had set up to view in these dark skies of Texas.

A thin crescent moon hung low in the western sky about 70 minutes from setting — barely detracting much from views of deep-sky objects in the many telescopes. As soon as I spotted Omega Centauri — naked-eye — a good distance over the mountains to the south, I stumbled around to look for the largest telescope that I could find. It fortunately turned out to be a home-mounted 17.5-inch Dobsonian — and it just happened to be looking at the cluster.

I asked to share the view, then stepped up to the eyepiece to encounter an experience that words can never adequately describe. Time went by. My eye was literally glued to the ocular until the instrument maker offered to reset the telescope — but I assured him that I could operate a Dobsonian. Time

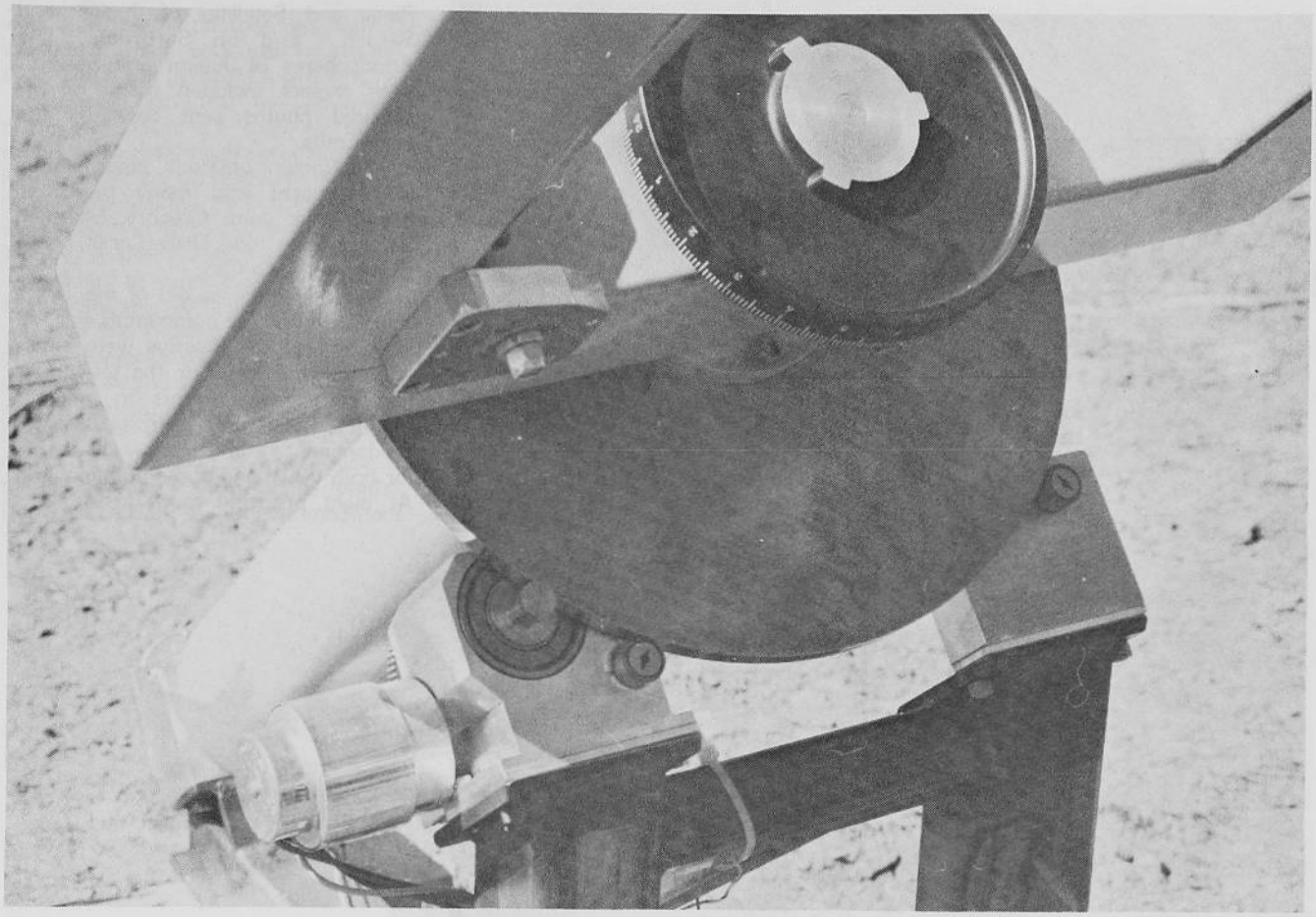
The courage of the man was evident as he described how he sat in the observer's cage at the focus of the 150-inch telescope in Chile riding out an



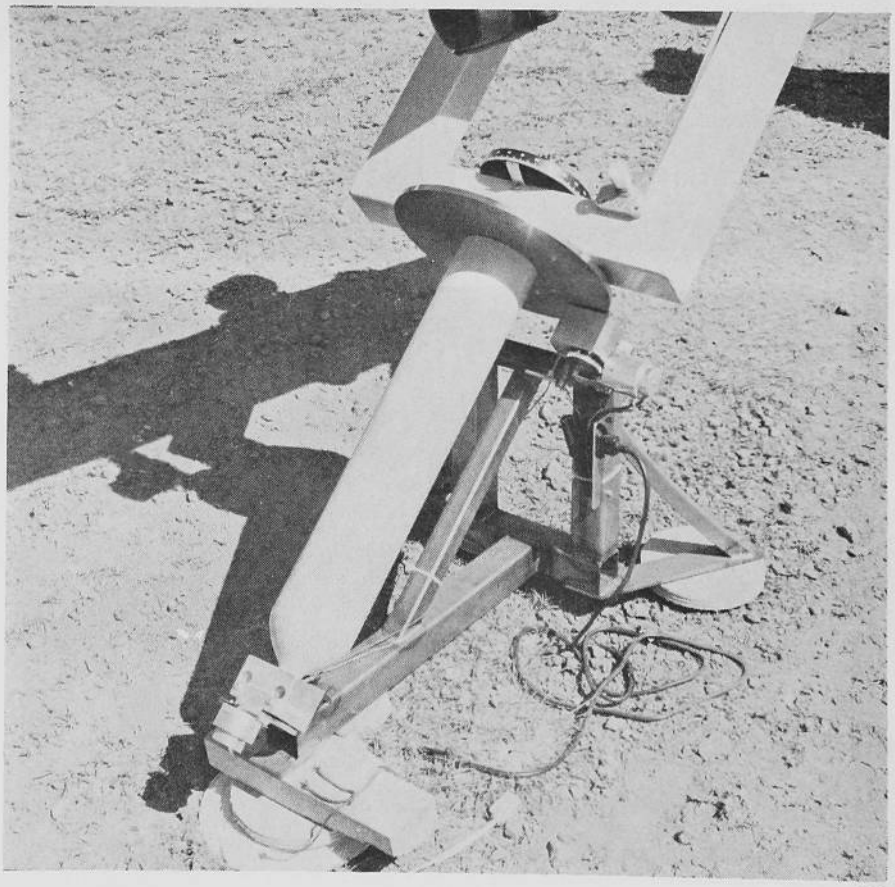
Gary Rusinger of Blue Springs, MO, brought a 20" Equatorial Newtonian with a very ingenious focusing mechanism. The instrument received an award for excellent machine work.

earthquake! His coolness and presence of mind (he immediately pushed in the dark slide cover and saved the exposure then in progress) at the age of 75 was something: he calmly looked in the guiding eyepiece and watched the star fields, clusters, and nebulae sail past while the instrument slowly settled back into position. He then withdrew the plate slide and finished the exposure (we saw a slide of the final picture)!

Few meetings I have attended in the past few years had such outstanding professional papers given. Dr. Karl Henize, astronaut-astronomer from NASA, started the procession on Friday with "Shuttle, Spacelab and Space Astronomy." His expertise is first-hand — and he will probably fly aboard the Shuttle in 1984.



Mark Kelley's friction disk drive was a well-done realization of an important, but somewhat neglected, method of driving an equatorial. Kelley comes from Boulder, CO.



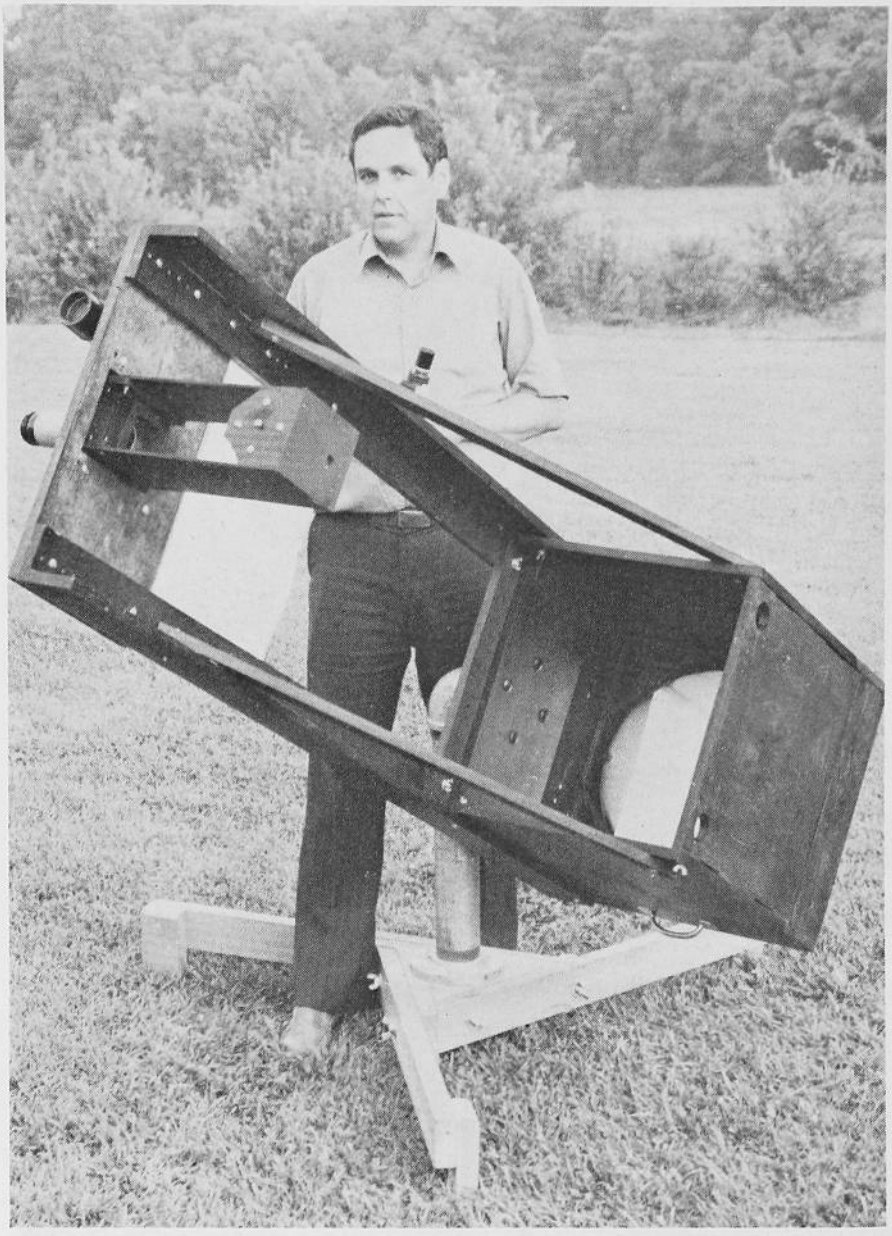
A fascinating panel discussion on "The Promise of the Space Telescope" a short time later with Dr. Henize, Bart Bok, and Harlan Smith became quite lively as Dr. Smith, director of the McDonald Observatory, defended his 300″ ground-based telescope project against the future of space telescopes. It ended on a friendly note, however.

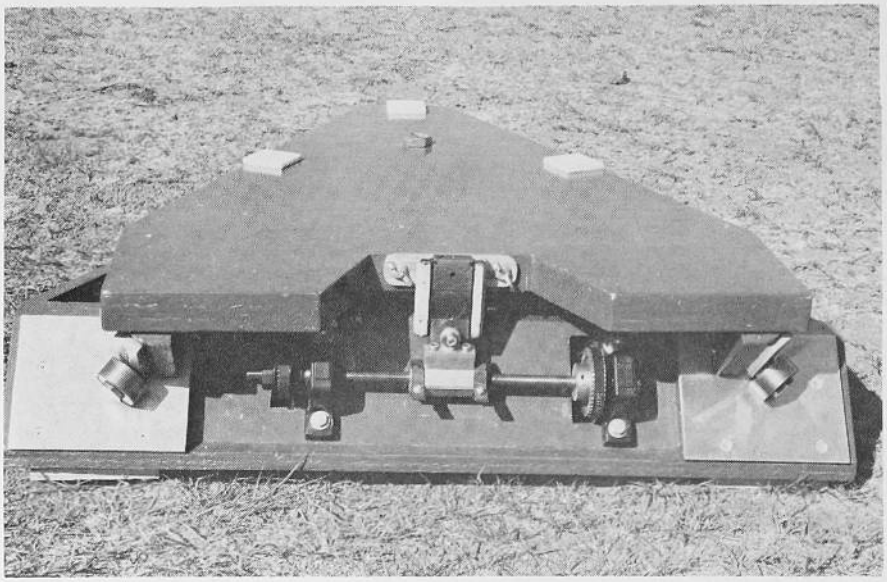
On Friday evening, Dr. Harlan Smith's presentation; "The Proposed 300″ Texas Telescope," describing the design approach and problems that have been and are being solved, was a thrill to the avid telescope maker. Both on Friday and Saturday, Dr. Reta Beebe of New Mexico State University and the Voyager Imaging Team presented papers on results from the Voyager program. On Friday, she discussed "The

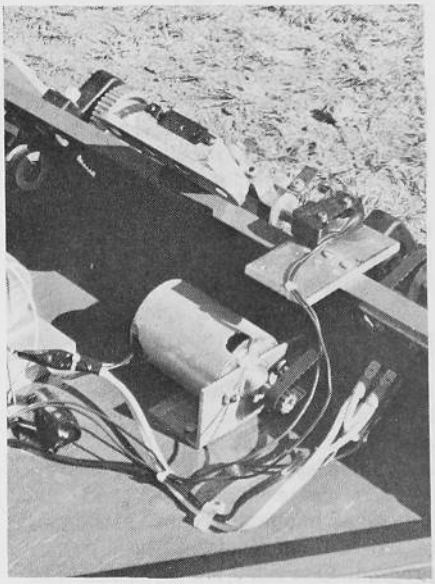
Rings and Satellites of Jupiter and Saturn," and on Saturday "The Atmospheres of Jupiter and Saturn." Both papers included many of the splendid photos sent back by the spacecrafts.

Well-known amateur personalities were present and many presented papers also: John Gregory, Sherman Schultz, Mike Jone, Diane Lucas, David Eicher, and Bob Cox.

One interesting aspect of the Texas Star Party was the commercial side. At least 90% of the displays were either entirely commercial or the telescopes had commercial mirrors in amateur mounts! Celestron's instruments were predominant — and many were set up for both visual and photographic work. At night probably more instruments







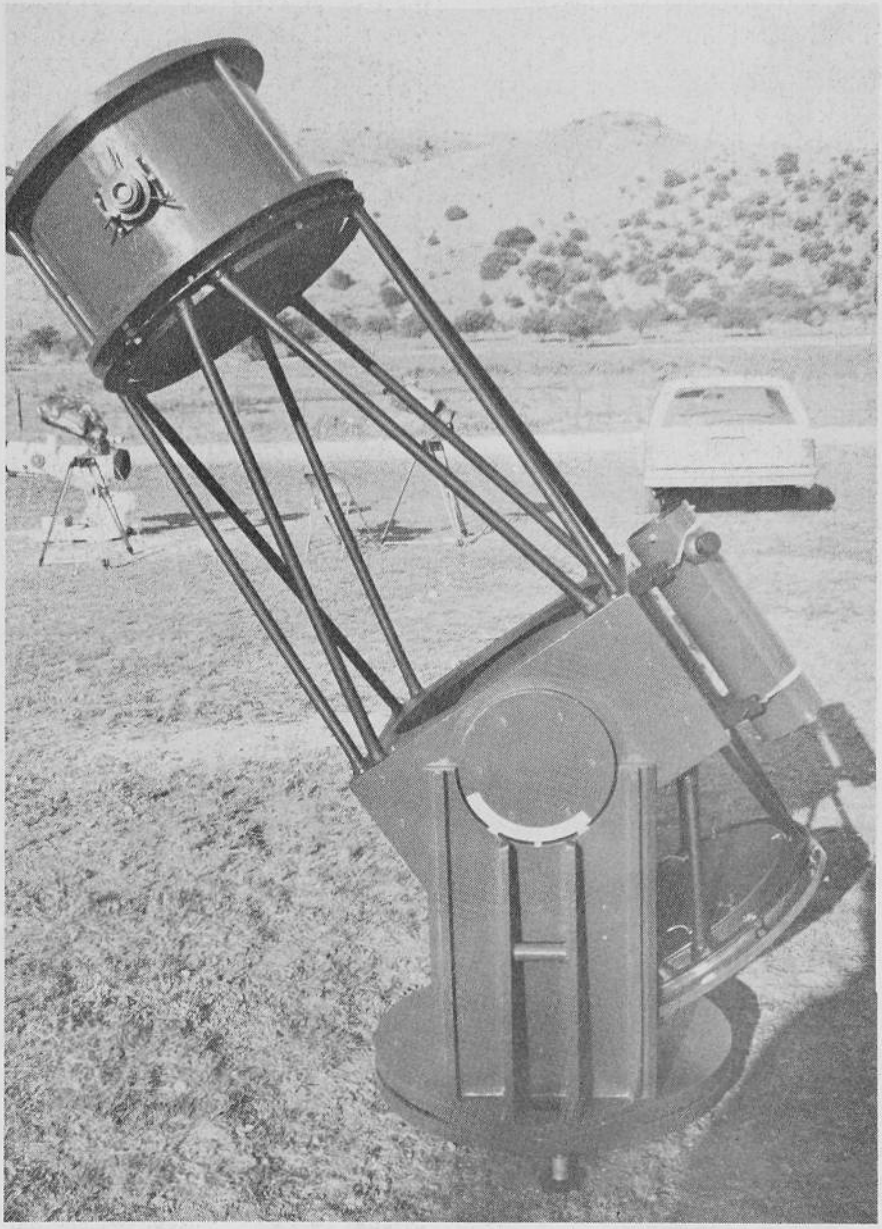
Thane Bopp won an award for "most portable design" with his 17½" alt-azimuth mounted Newtonian.

"The Finest Poncet platform I have ever seen" was built by Tom Martinex of blue Springs, MO. It features a fast return mechanism and "internal" drive motors.

were busy taking photographs than in visual use, which made walking around even with a red flashlight a problem.

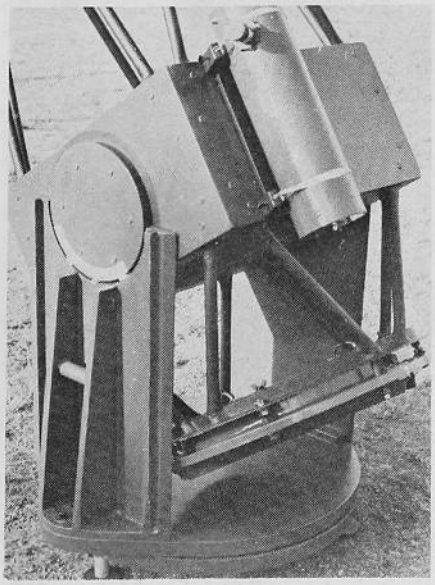
Everyone, including the photographers, was treated to a "super-blackout" on Thursday night when a problem at the local electric station resulted in the loss of all power between 11 p.m. and 3 a.m. I was caught in the living room of my sleeping quarters when the blackout hit — and had to stumble over all sorts of stuff to find my red flashlight.

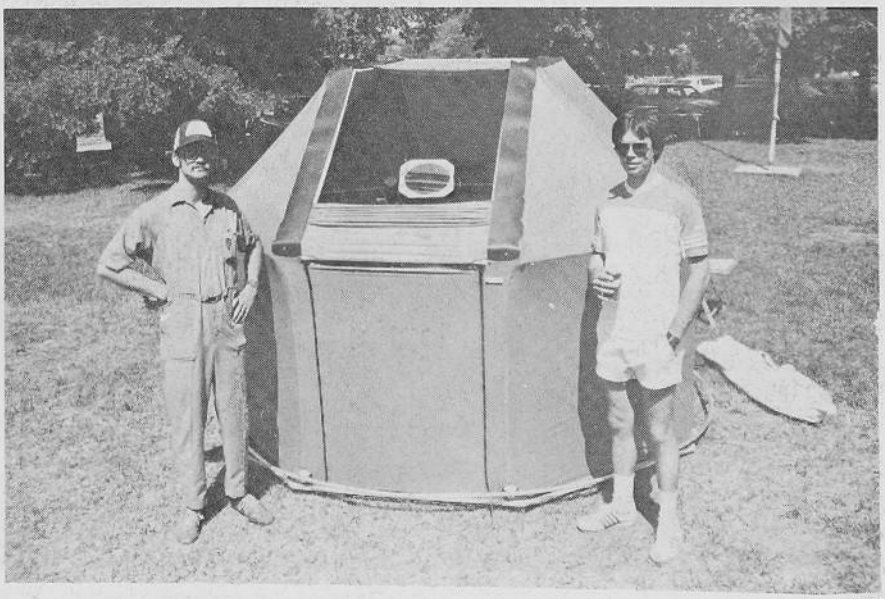
Earlier that evening several bus loads of the delegates visited the McDonald Observatory and with great anticipation, after some film and talk presentations, lined up for a view through the 82" reflector. Unfortunately, there was a major problem with high winds. Recording equipment on the mountain



Jim Meketa of Newton Centre, MA brought an award-winning 18" f/4.5 Dobsonian. Set-up takes about ten minutes, and the heaviest piece weighs 54 pounds. The mirror is from Star Instruments and the flat from E&W.

Andy Lauer displayed a portable cloth observatory. If those cold gusts are getting you . . .





from the SAAA Newsletter

showed it reached 35 mph with gusts to 45 mph — and the astronomer present said that another 10 mph and they couldn't safely open the dome. However, we did look through the 82″ telescope, but that is all one could say due to the seeing conditions: Saturn appeared much as it must have been seen in Galileo's original telescope, a smear of light with extension on either side.

We were one night too late: the night before they'd had 2 arc-second seeing and we would have had a fine view.

As with most telescope meetings, the abundance of fine instruments was inspiring. In spite of poor seeing — which seriously limited performance on planets, Moon and double stars — deep-sky objects were outstanding. One of the finest views I've ever had of M-51 was through a 12.5″ with the object high in the skies. Some of us hoped to photograph the Omega Centauri cluster through Gary Ruisinger's 20″ trailer-mounted Newtonian which he had brought down from Blue Springs, Missouri, but the continuing winds made this impossible.

Missouri was well represented with Tom Martinex, president of the Kansas City Astronomers Club, displaying an excellent 17.5″ Newtonian on a Dobsonian mount set upon a clever and well-made Poncet Table. Tracking time is limited to one hour but after the drive shuts down by micro-switch, a second drive motor resets the mount at a high speed for continued observing.

An award for outstanding mechanical design was given to James Meketa of Newton Center, Massachusetts. His modified Dobsonian featured two trunnion altitude arms instead of the usual box construction, setting circles, and a computer program for finding sky objects.

Larry Paulk of Houma, LA, had 10″ and 6″ fork-mounted Newtonians with an ingenious Teflon mounting that was also an award recipient. The outstanding junior ATM award went to Walter Whitaker of Dallas for his 4.25″ Newtonian on a Dobsonian mount.

Commercial optics could not be considered for optical excellence, so only 12 entries were offered for evaluation, and of these, only two were awarded merit certificates, one to Charles Whitaker of Dallas for his 8″ Newtonian, and the other to Eliot Neel of Fayetteville, Arkansas for his 4.25″ R.F.T. Seeing was poor, but evaluations were made on inside and outside focus diffraction patterns and also on a bar target set up on a distant hill by Mike Jones of Fort Worth.

People planning to attend telescope meetings and place instruments for optical evaluation should ensure the optics are mounted properly mechnically and in good alignment. Most of the 10 who did not qualify for an award had these problems. One 12.5″ folded telescope had a pinched secondary flat that distorted the image and we were forced to disqualify it.

A special award for distance was given John Riley of Portland, Maine for attending the meetings.

Unlike Riverside, where the recipient of the Clifford W. Holmes award must be in attendance, the Texas Star Party "Lone Stargazer Award" for outstanding service to amateur astronomy was awarded to Walter H. Haas of ALPO in absentia. Everyone agreed, however, that he was a worthy recipient and a most deserving person!

Dr. Harlan Smith, director of McDonald, had stressed the fund raising for the 300″ telescope, so right at the registration office was a special container for contributions from attending amateurs which, when combined with a special sale of a 6″ war surplus catadioptric system for $200, brought the contributions from the Texas Star Party to a total of $720.

It was unfortunate that this year's Texas Star Party conflicted with the Riverside TMC, but it's apparent from reports that I've heard that neither event suffered. Both had excellent attendance, fine instruments, and good stargazing.

Next year's Texas Star Party is planned for early June. If you go, plan on having an excellent time — and feeling afterward it was time well spent.

— Robert E. Cox

A 24″ Equatorial Reflector
that was homemade and is portable!

Less than a year ago Byron Melland and I got the urge to build a large telescope. What's amazed us is how all the right things came together to make it happen. Today we have a 24-inch telescope. It is owned jointly by the Pomona Valley Amateur Astronomers and the Webb School of California — but that's getting ahead of the story.

Starting the Ball Rolling

Byron and I are both members of the PVAA and I teach physics at Webb School. Either of these groups could conceivably have sponsored the project. We didn't particularly care about owning a large telescope — we just wanted to be able to use one. But as it turned out, we brought both groups into the picture. Gene Fair agreed to donate a mirror blank to Webb School. The school agreed to pay for the figuring of the optics and to have the PVAA build the telescope. A committee from the club met with the headmaster of the school to negotiate a joint-use agreement.

Both groups benefit in this kind of arrangement. The school is getting a major telescope for the cost of the optics alone and without the hassle of a major construction project. The school also has the club to help maintain the telescope, outfit it with accessories, and act as a resource for the students to draw upon. The club has avoided a large cash outlay, but could pay with what it had — the telescope and trailer, built largely of scrap materials, required about a thousand man-hours of work in Byron's garage. Man-hours, not money is what a club is all about.

Another advantage for the club is that we have a place to house the telescope. No single member has had to donate garage space for the telescope once it was finished.

The Design Concept

The PVAA chose a design committee consisting of Byron Melland, a truck mechanic with several key skills, tools, and sources of scrap parts; Jeff Schroeder, known for his 11-inch portable refractor; Bob Chambers, astronomy professor at Pomona College; Tony Cook, operator of the 12-inch Zeiss refractor at Griffith Observatory; Tony's brother Vincent Cook; and me, maker of the Volkscope before Coulter's Odyssey hit the market.

Everyone knows that the mounting for a good telescope costs more than the optics. Dobsonians may be an exception to this rule, but we chose an equatorial mounting because we wanted to do photography, photometry, spectroscopy, and anything else we might want to attempt some time in the future. To have such a telescope at a low cost would require several innovations.

For one thing, we had the choice of a 3″ thick by 20″ diameter mirror of crown glass, made from the blank that was actually donated to Webb; or a mirror half that thick and 4″ larger in diameter and made of Pyrex, which was offered to us in trade. Supposedly, thin mirrors are a dubious proposition unless hung in a sling in a Dobsonian mounting, but we opted for the large, thin mirror anyway for several reasons. First, the advantage of the rigidity in a 3-inch thick slab of glass might well be nullified by problems with thermal expansion. Second, 4″ is 4″ — and there was strong sentiment among us that a possibly inferior figure, from support problems or whatever, on a large mirror was better than a good figure on a smaller mirror. Third, we felt confident that we could build a mirror cell that would support a thin mirror adequately. More on that later.

One potentially costly item we wanted to eliminate from the system was a large worm gear for the clock drive. Jeff Schroeder made his own worm gear and worm for his 11-inch refractor, but for this telescope we leaned toward alternative drives: belts, chains, rollers — anything but large worm gears. We eventually chose a smooth disk driven by a bicycle chain. Jeff had used a 30″ telescope with a similar drive system at the Stony Ridge Observatory near Mt. Wilson and had been impressed by its smooth performance. The disk rides between the side plates of the chain and is driven by friction. When a force is exerted on the tube of the telescope, the disk slips, acting as its own clutch.

If you can imagine a 24″ f/5 telescope, i.e., a 10-foot-long telescope with a Newtonian focus mounted on a portable German equatorial, you have a good imagination! Size alone led us to choose the more compact fork mounting despite potential problems with flexure in long fork arms. The desirability of short fork arms led us to think about keeping the center of gravity as near as possible to the mirror, which led us in turn to considering a lightweight open tube assembly. The front end of the tube assembly is 1″ tubular aluminum, while the back end is a steel box.

The dominant construction material in the telescope is steel. Its weight is not a problem with a trailer-mounted telescope, and its rigidity is an asset. We were not determined to build a heavy telescope, however, so we used square or rectangular steel tubing wherever possible because of its large stiffness/weight ratio.

Steel structures are easy to fabricate with a cutting torch and an arc welding rig. As the design emerged, we saw that there would be very little need for machining — which was fortunate since we were dealing with rather large parts.

Construction

Byron and I did most of the actual construction, although others pitched in with money, materials, and services at key junctures. We were considering 4″ diameter steel tubing for the polar shaft

until Byron came home with a front spindle and a set of bearings from a Peterbuilt truck. The diameter at the front end is about 3⅛", but it is solid cast steel and is designed to carry 9000 pounds at high RPM. There was still some skepticism from some members, but with a finished product before us, doubts vanished: there are a lot of other things on the mounting that will flex before the spindle does!

One major job was machining the seats for the bearings. We obtained two slabs of 1"-thick steel plate and gave them to Bob Chambers to have turned for us in the Pomona College machine shop.

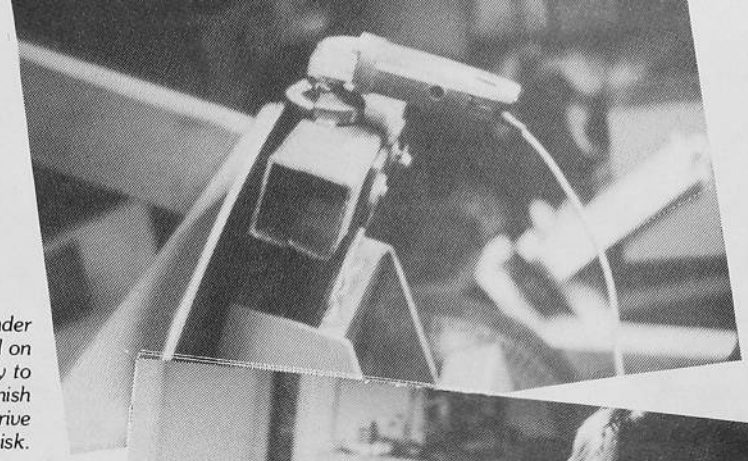
The only other major machining job was the 30" diameter drive disk. Rather than send it out to be turned on a mammoth lathe, we decided to do it ourselves. Here's how: we bolted the disk with spacers to the back of the fork arms, mounted the fork arms in the bearings, welded a rack and lathe tool holder to the frame, and proceeded to turn the disk, rotating the fork arms by hand. It worked beautifully, although admittedly it took a long time. We finished off the job by fastening a hand grinder to the rack in place of the tool holder.

After we finished the telescope, Bryon spoke with someone who have been involved in building a large telescope with a similar drive back in Ohio. That person reported problems with concentricity that made the chain bind in certain positions. Whatever the drawbacks of our method, lack of concentricity is not one of them.

The trailer is built up from the rear torsion bar suspension from an Audi. We got it, complete with wheels, for about $80; and Mel Hornbaker, one of the club members, donated tires. The trailer is simply an A-frame welded onto the torsion bar housing. While traveling, the mirror rides in its cell resting on its back supports — we decided that taking the mirror in and out of its housing would be much more likely to damage it than letting it ride in the cell. "After all," we asked ourselves, "which is the better place to ride, on an Audi suspension or in the back of a pickup?"

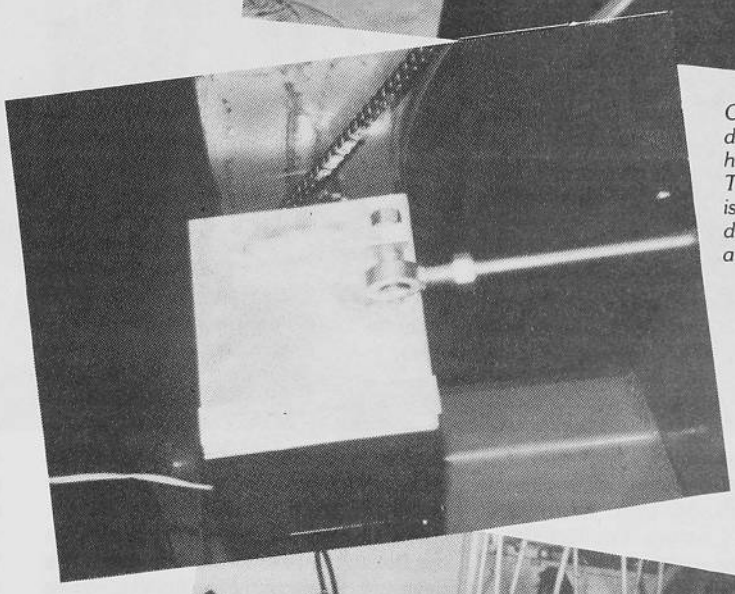
The finder, focuser, and diagonal holder are small items usually bought commercially even for most home-built telescopes. We finished ours with innovations in all three departments. The diagonal holder is a folded piece of reinforced sheet metal with a bolt to adjust the degree of tilt. Adjustment is made by rotating the diagonal mirror on its support shaft and by adjusting its tilt.

It might seem that three angular degrees of freedom would be necessary to orient the mirror, but one of them is largely redundant. In terms of a

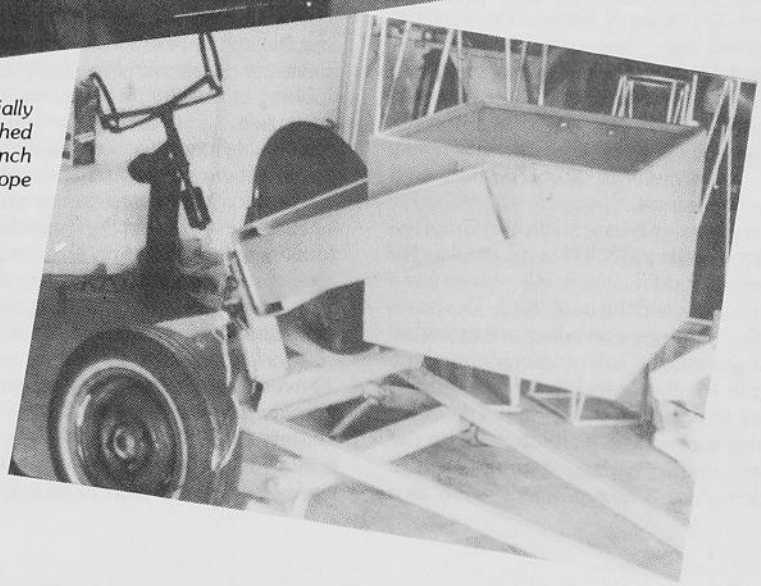


Grinder mounted on frame ready to put final finish on the drive disk.

Bryon Melland grinding drive disk.



Clock drive and drive corrector are housed in the box. The tensioning bar is used to adjust drag on the disk and chain.



Partially finished 24-inch telescope

coordinate system where the X and Y axes lie in the plane of the mirror and the Z axis is perpendicular to it, rotations about the X or Y axis will deflect the reflected light, but rotation about the diagonal support has a component about both the Y and Z axes. Despite the simplicity of the diagonal holder, it works beautifully. It holds the diagonal rigidly and adjustment is accomplished with only one screw.

The focuser is essentially the Crayford design shown in TM#11 on page 18 with a couple of modifications. We did not use a spring, but used the base itself. The posts for the bearings and roller are mounted on a piece of ⅛" sheet aluminum with a tight fit for the draw tube, and this base flexes to serve as the spring. The other change we made is a clutch plate on the roller shaft which eliminates the tendency for a heavy object, such as a camera, to turn the roller. We have even attached a video camera directly on the draw tube with no additional support.

We have made our own finders. On the box at the base of the telescopes, we have two projection-type finders. When looking at the sky through one of these, one sees a partial reflection of an illuminated circle focused at infinity. The circle appears to lie among the stars and makes pointing the telescope quick and accurate. One simply matches the location of an object on a star atlas with the corresponding pattern in the sky. This method is particularly good when the stars one is using as reference points are too far apart to fit into the field of a conventional finderscope. We illuminate the target with a red LED — so the battery will last for months even if the switch is inadvertently left on while in storage. We also plan to mount a small conventional finder at the eyepiece to ease the situation for the person on top of the ladder.

For stability, we put jack stands on the rear of the trailer and are in the process of putting an adjustable jack stand on the front to allow precise polar alignment. We plan to add a rack for a battery (we will use a sealed battery to avoid acidic fumes near the mirror coating), a built-in 2-axis drive corrector circuit, and to weld accessory cases and a tool box to the frame.

The mirror cell required special care because of the thin mirror. Early in the planning, Paul Jones of Star Instruments (who figured the mirror, and very nicely, I might add) informed us that there would be a 2-inch hole in the center of our mirror because of the way he holds it for grinding. I suspected immediately that this would be the ideal place to give the

mirror lateral support in the cell. A plug through the center would eliminate the need for clips around the edge with the attendant strain points.

Kim Gordon, a friend of Paul's who had mounted a mirror in a similar way, suggested wrapping the plug with Teflon tape. Teflon flows enough to relieve any initial stresses from the fit. This is the method we decided to use.

The back support for the mirror is an 18-point floatation system. The disk is divided into six equal sectors, and each sector subdivided into three sections of equal weight. A triangle is placed in each sector with a corner pad supporting the mirror at the center of gravity of each section. The six triangles are supported in three pairs with bars, and the centers of the three bars pivot on the corners of one large triangle.

Although everything rocks, the pieces are pinned to prevent them from moving out of position. When the mirror is set on the cell, each point supports an equal weight and everything becomes rock solid — gravity holds the cell against the back supports and the central plug holds it laterally. The trick is to derive the locations of the points for uniform support given the diameter of the mirrors, the radius of the central hold, and the curvature of the front surface. While the latter condition is probably not significant in most cases, I worked it into the problem anyway — what the heck. It took a couple of double integrals to derive the formulas, but it was a good review of calculus for me — I have even used it as a example problem for my students.

I then put the resulting formulas into a BASIC program that will crank out all the necessary parameters for any 9 or 18 point floatation system.

Both the optical and mechanical performance of the new telescope has exceeded our expectations. Our first test of the system was on a trip to the Borrego Desert with a group from the school. The ride of the trailer was very smooth and it tracked perfectly. Although it takes two people to detach and maneuver the trailer conveniently, the remaining tasks, i.e., setting up the tube assembly and all other operations, can be accomplished by one person.

The clock drive and clutch system is very smooth. The tension of the drive chain is easily controlled, and not much tension is really needed. It's an easy matter to manually center objects in the field even from the top of a 10-foot ladder. One addition we quickly found we needed was a light baffle — the open frame work all the way to the front of the tube doesn't stop any light. While it may be fine inside a dark observatory dome, when there is any moonlight or other stray light in the background, glare

enters the focuser around the diagonal mirror. We cured that problem by pop-riveting sheet aluminum around the front end of the tube.

The Borrego Desert trip was a disappointment as far as testing the optics was concerned. There was some moonlight, high clouds, and absolutely terrible seeing. Even after the Moon went down and the clouds cleared off at 3:00 a.m., the turbulence washed out all detail on the surface of Jupiter and made globular clusters look like huge unresolved cotton balls. We had other telescopes along, so we knew the problem was in the atmosphere, but it was disappointing not to be able to evaluate the optics.

The test of the optical system had to wait a few weeks. We took the telescope up to Mt. Baldy, our club's local observing site. The first thing we looked at was Jupiter. Since Jupiter normally looks so good in smaller telescopes, I wasn't expecting anything much better in the 24". To my surprise Jupiter was fabulous! Many more bands than usual were visible and there were noticeable swirls within them. I saw a couple of white and brown spots plainly although the Great Red Spot was apparently on the far side of the planet. The moons showed definite disks.

Saturn was another special treat — Cassini's Division stood out so that even a novice could see it immediately, and the Crepe ring was equally obvious. After seeing the Crepe ring in the 24", I was able to pick it out in a 6", but I would never have trusted my identification on the basis of what I saw in the 6" alone.

The most impressive planetary view was Mars. Moments before checking out Mars in the 24", I was looking at it in a C-8. I could see the polar caps and some dark markings — in fact it was near opposition and looked better than average. When I went to the eyepiece of the 24-inch, I couldn't believe my eyes. The contrast in the coloring was vivid: polar caps were glistening white set against the deep orange of the lower regions. Dark markings were sharply outlined, and in the orange background there were hints of finer detail still. It was the kind of view to give canal hunters a field day.

Beyond the planets we checked out a few deep-sky objects that had potential for new revelations. The Black Eye Galaxy showed the large dust patch as easily as looking at the photographs. In a 12" it is there, but it requires good observing skills to see it. The Whirlpool Galaxy, M-51, filled the field with blatantly obvious spiral structure even though the background sky was not the best. In the Ring Nebula, the central star was clearly present. Scanning through the cluster of galaxies in Virgo we were looking into considerable light pollution, but small galaxies were everywhere, and they showed individual differences in structure.

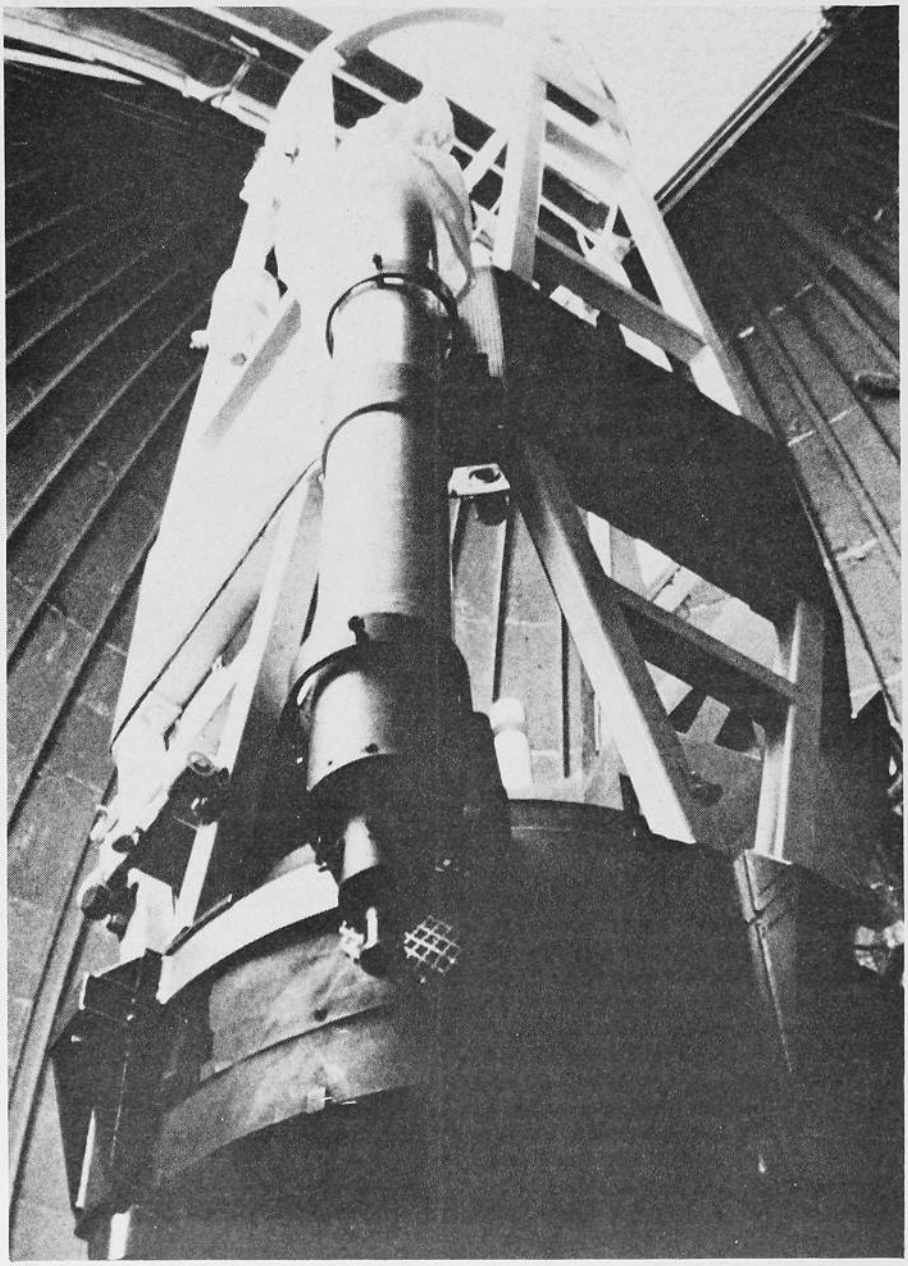
Probably everyone's favorite view that night was the Hercules Cluster, M-13. No matter how large a telescope is used, globular clusters keep getting better and better. There are so many faint stars that every increment in aperture enriches it more. The four page photographic sequence on M-13 in *Burnham's Celestial Handbook* illustrates the effect well.

One more accessory we intend to add to the 24-inch telescope is an observer's log and sketch book. Many people will be using the telescope and they will each have contributions to make and excitement to communicate. The joy of sharing the view beats the joy of exclusive ownership any day.

David Chandler
1175 W. Baseline Rd.
Claremont, CA 91711
■

MARSHAL MARTZ'S

76-cm Telescope



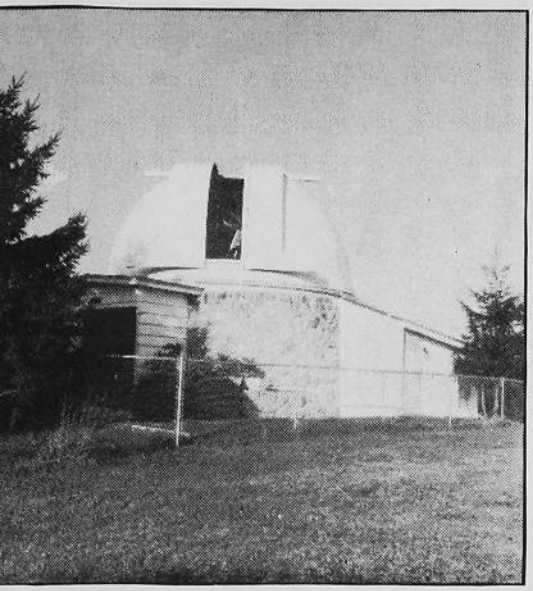
One of the largest one-man-made telescopes in North America stands near the Pennsylvania border south of Jamestown, New York. Marshal Martz (1910-79), long a professor of astronomy, optics, and physics at Jamestown Community College, began building the 76-cm (30-inch) behemoth more than 20 years ago. By 1965, it was in operation, if not perfected, in an observatory adjacent to his house. His wife and followers now use it for the Marshal Martz Memorial Astronomy Club of Jamestown, and continue developing the facilities Martz began.

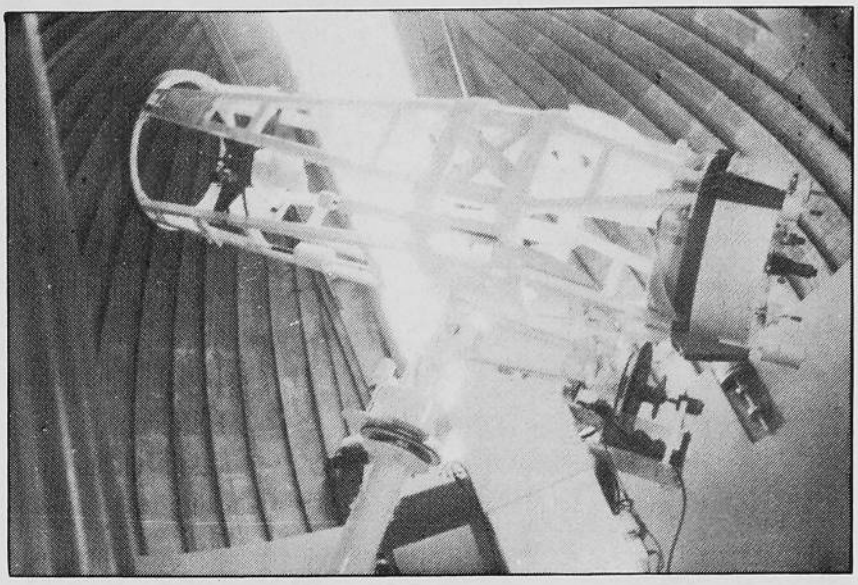
Martz ground the 1:6 Pyrex mirror, welded the trussed skeleton tube, hobbed the gears for the drive, built the brick pier, cut the dome slit, and welded the shutters. Virtually every feature bears the imprint of Martz's design, from the electric-powered observing ladder (he was confined to a wheelchair toward the end) to his signature welded on the mirror cell. A good example is the sheet of screen that prevents busy fingers from changing adjustments on the cell.

Interchangeable secondaries allow for a Cassegrain focus, though it is not presently in use, and two alternative Newtonian eyepiece holders of 1.25″ and 2″ diameters. Images were not as sharp as they should be the one evening I spent there, which might be due to seeing (which is poor in the lee of Lake Erie) or thermal shock, or to a more serious optical problem. Plenty of eyepieces are available.

Martz Observatory still could use more improvements. The dome slit is only a little wider than the aperture, a nuisance that often blocks the finder scope or the main scope unless the dome is frequently rotated to keep pace. The addition of a red-light system would greatly aid working in the dark observatory.

But the setting circles are right on, the





Martz Telescope and Observatory

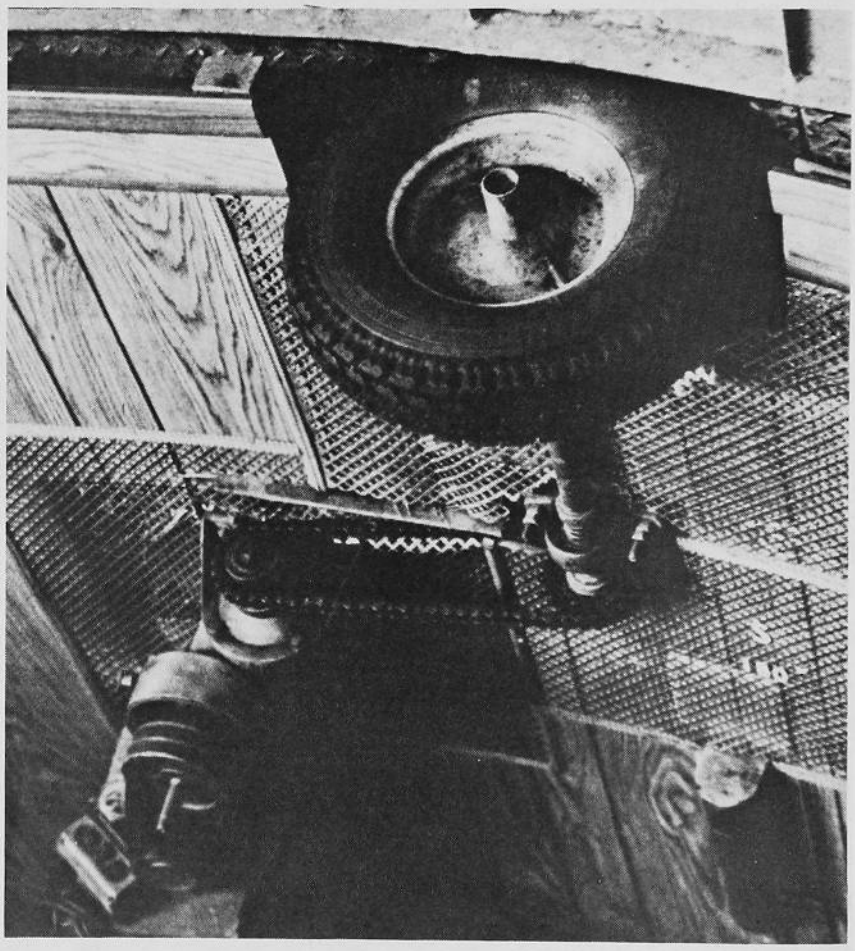
This telescope and observatory was designed and built exclusively by Prof. Marshal S. Martz assisted by his wife, Mary; his mother MaBelle Martz and his wife's mother, Nora Kirkner.

The telescope and observatory were completed in the year of 1965 for the purpose of studying the heavens and to be made available to all who desire to observe the wonders of the universe.

MARSHAL S. MARTZ

1910 - 1979

Dedicated by his loving wife, Mary, to the memory of his many years of effort and sacrifice to leave this legacy to the world.



finder centered, the workshop well-stocked to finish the spectrohelioscope Martz began, and the library abundantly endowed with reference books for the use of club members. The establishment is good enough right now to start serious photometry, bright-star spectroscopy, and occultation timing. With some improvements, inner-sanctum variable monitoring could begin, and Martz Observatory would become a candidate to join the National Amateur Astronomy Observatory Network now being set up by the Astronomical League. It is already a striking memorial to the genius of the man who built it, and has the potential to be a real showpiece. Astrofolks traveling near Buffalo and Erie should consider a detour to see and use this huge amateur telescope, and if you see club leader Phil Moniot at a convention, be sure to have a chat with him. The observatory is located in Frewsburg, NY. Contact Phil Moniot (RD #1, Ashville, NY 14710, phone 716-789-2108) for tours or information.

Norm Sperling
Everything in the Universe
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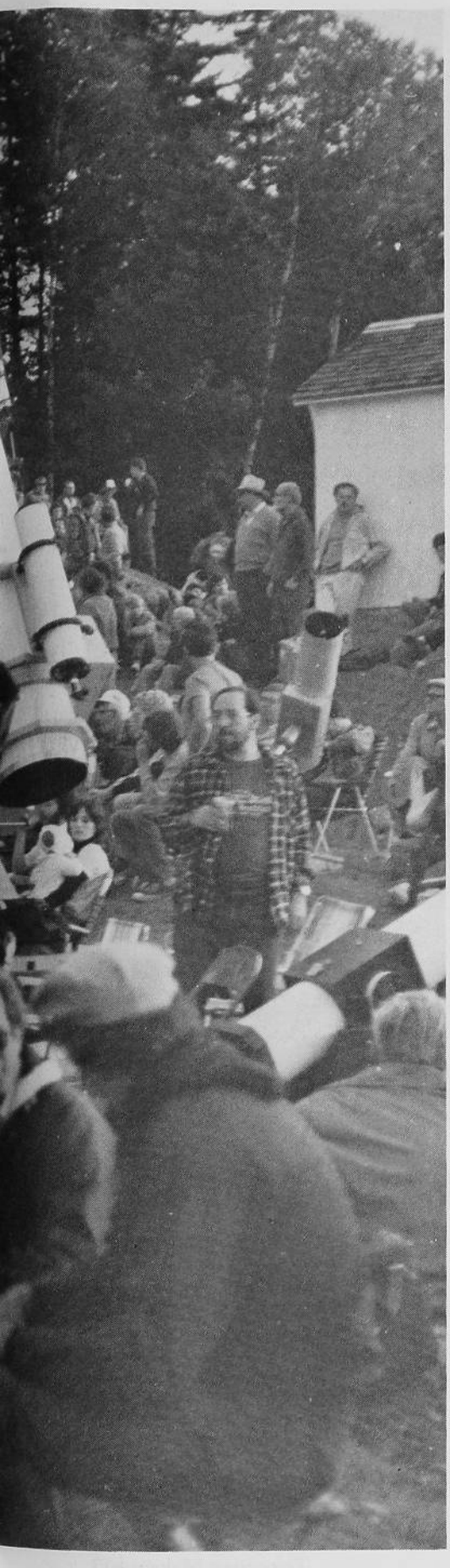
Oakland, CA 94609

■

Telescope Making #17



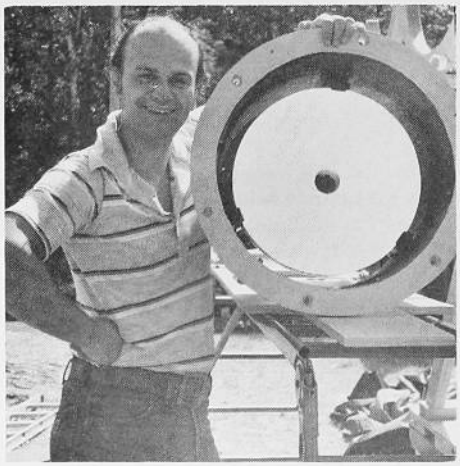
STELLAFANE • 83

Above: Roland Christen peers through an apochromatic triplet "object glass" he had just finished. Its performance was, to say the least, pretty darned impressive; the extrafocal diffraction rings were the finest I've ever seen.

This year, the evening speakers spoke from a little dias at the head of the trail from the field rather than from the back of the Turret Telescope. But it was a fine Stellafane: lots of people, lots of telescopes, and some fine speakers indeed. I have usually skipped the talks under the tent: this year I listened to many of them. Just a reminder to those I asked to send me their remarks as an article for TM: please remember you have something to tell the world!

Stellafane Shadowgram

"In the 60s, we suffered from the 'woodsman, woodsman, spare that tree' syndrome. Well, I started a surreptitious, unAmerican, and unconservationist campaign. Everytime I came up here, I'd cut a tree and let it fall. A week later, I'd cut another. You know, it used to be you couldn't see Mount Ascutney from the steps of the clubhouse. A decade later, you could see Mount Ascutney. I'm proud of that fact."



portable precision optics . . .

Mario Motta of Tewksbury, MA, was packing up his 16" portable fork-mounted Cassegrain/Newtonian Sunday morning. He displayed his prize-winning mirror, and discussed the fine points of the 500-pound wooden fork. It has a frame of 2½ x 3½ hardwood beams and 3x4 cross beams bolted and glued together, then sheathed in ¼" plywood. The 3" diameter polar shaft goes all the way through the fork and is attached to the wood structure with heavy metal plates.

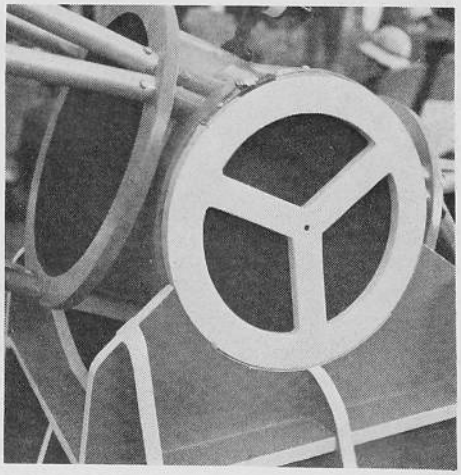
A lot of effort went into planning how the instrument would travel. Like the Space Telescope, most of the beating a portable telescope gets is "on the road" experiencing 3 Gs vibration in all axes! Motta supports the fork with a pair of 2x4s that prevent the tines from bouncing, and the end of the tube with a plywood support that doubles as an observing table. The mirror, which won a prize for optical quality, comes off the tube still in its cell, which is indexed into place by cut-off nails and held by ¼"-20 bolts.

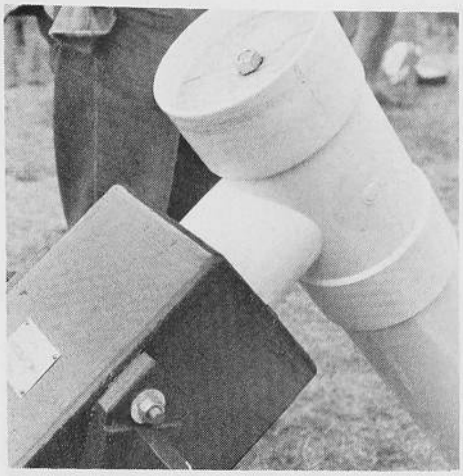
. . . and long focal lengths

Alan French broke new ground with his very distinctive 10" f/9.5 Dobsonian planetary telescope. It features a mirror made by Alika Herring in 1950, a 1.25" minor axis diagonal mirror to reduce diffraction effects of the secondary, and an open tube for improved thermal equilibration and reduced tube currents.

The lower end of the tube is built up from wood and spiral wound paper, and the upper end is an open "Surrurier" truss of aluminum tubing. The lower end is ½" thick felt form material; French made the side bearings from the same material cut into an overlapping shape, glued it on with waterproof glue, and sculpted the joint for appearance with Bondo car body filler.

The base is a bit more complex than the usual Dobsonian — while it rides a ring of Formica, the base drops into a hollow ground board. The telescope is made especially distinctive by the paint scheme: a light color on the edges of structural members and a dark color on the sides.





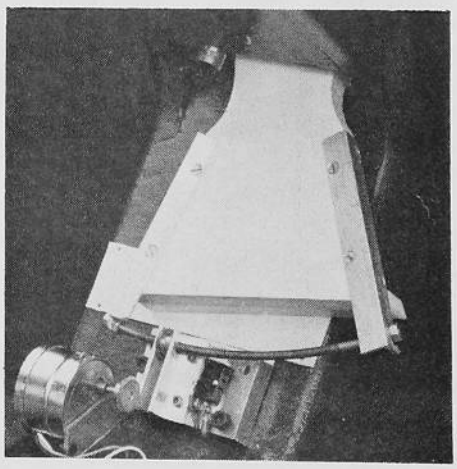
PVC on Teflon bearings . . .

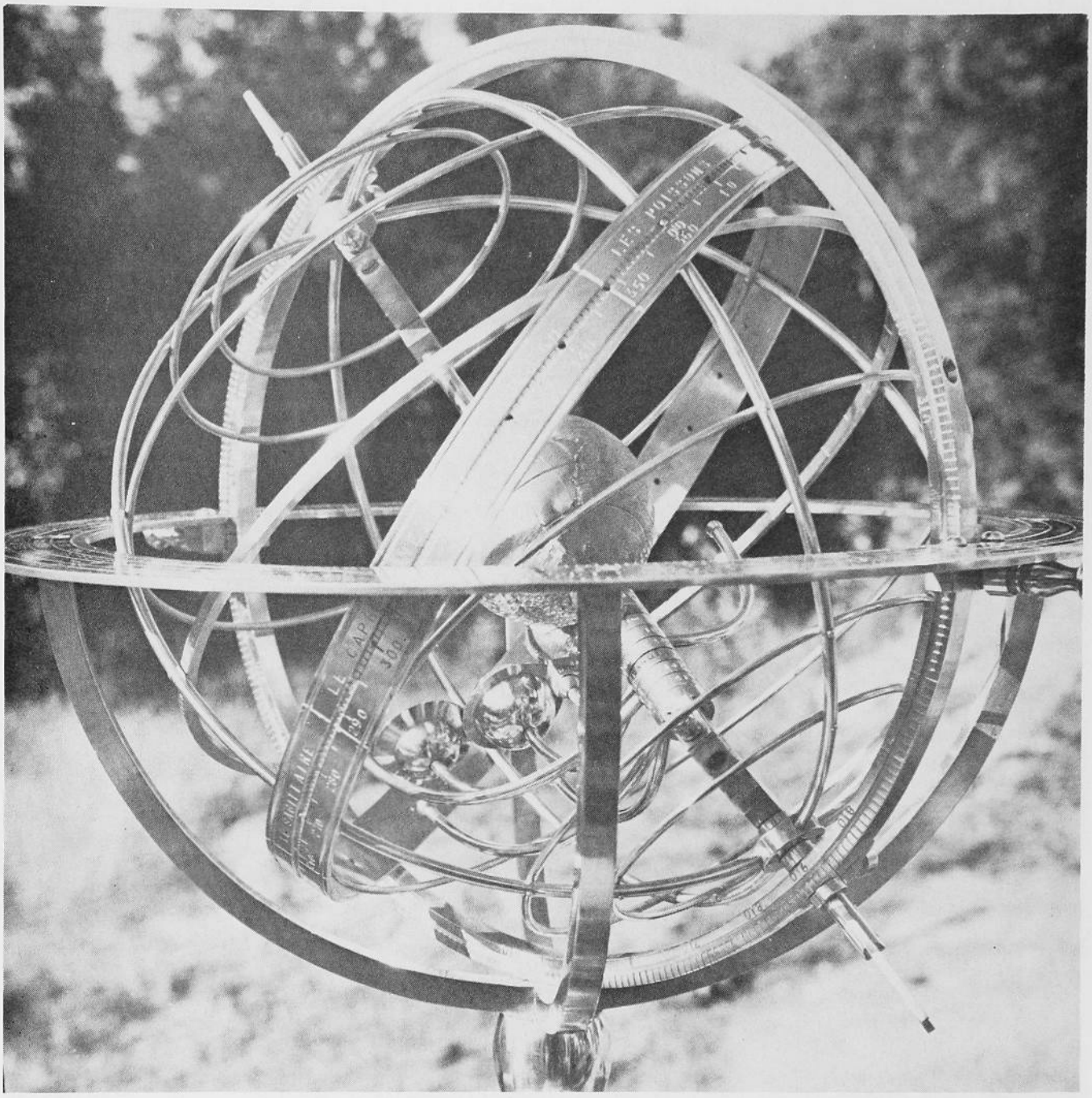
Roach and Hotten's equatorial mounting looks a little different, but it's very sturdy, damps rapidly, and cost them only $150 in materials. "It has one, count 'em, one machined part," said Roach. The mount is built from heavy PVC pipe filled with concrete, and rides on Teflon pads. The polar base is a 1" plywood box, and the axis is 4" diameter PVC pipe. The thrust surface is at the top of the box: two little strips of PTFE, and two radial surfaces on the bottom, inside of the hole. The other radial surfaces are two pads inside the box against its top surface. An "anti-crunch" pad prevents loss of contact with them. The polar drive sector clamps to the pipe via two hose clamps that operate in opposing directions.

. . . drives of threaded rod

The PVC pipe is concrete-filled and the concrete is reinforced with threaded rods. The pipe tee is a 4x6x6, concrete filled, and machined flat on its 4" limb where it turns against the Teflon pads. The declination bearing is the three radial pads and three wide longitudinal pads on the bottom of the telescope plate, and is held by a ⅝" diameter threaded rod that runs the length of the declination axis. A slow motion sector gear attaches around the rim of the pipe.

The long end of the declination shaft serves as the counterweight. It may be concrete filled or left empty depending on the weight needed. The telescope shown at Stellafane had a sliding weight in the last 12" or so of pipe.





it's not a telescope, but . . .

"Sphere Armillaire de Ptolemae et Copernic" he called it, an armillary sphere that unites the two great world systems — and a work of art. Real Manseau of Drummondville, Quebec, began work on his sphere in September of 1981, and ended up making 356 pieces of brass and one piece of bronze (the Earth/Sun), including rivets, spending 400 hours, making the 23-piece walnut base for a finished product that stands 23½" tall and weighs 32 pounds. He also stamped all the constellations, signs, and data on the planets, divided the circles into degrees, put the history of astronomy from Thales to Newton on the base ring, crafted the Earth-Sun central globe, hand rolled the circles....

Why is this man hitting himself in the eye with a telephone handset? Actually, he's not. Alan Daroff of Philadelphia was observing the Sun with a hand-held TV monitor. The system, attached to a C8, uses a 0.42 Angstrom hydrogen alpha filter by Daystar and a Panasonic camera, a commercially available security unit with a Nuvicon 2/3" tube having high near-infrared sensitivity.

Stellafane Shadowgram

"The people walking this ground 50 years ago didn't know what they were doing. Well, the people changing a culture, or part of it, usually don't know what they're doing. But they were engaged in a revolution, a revolution that brought telescopes within the reach of people like you and me. Now it's happening again."

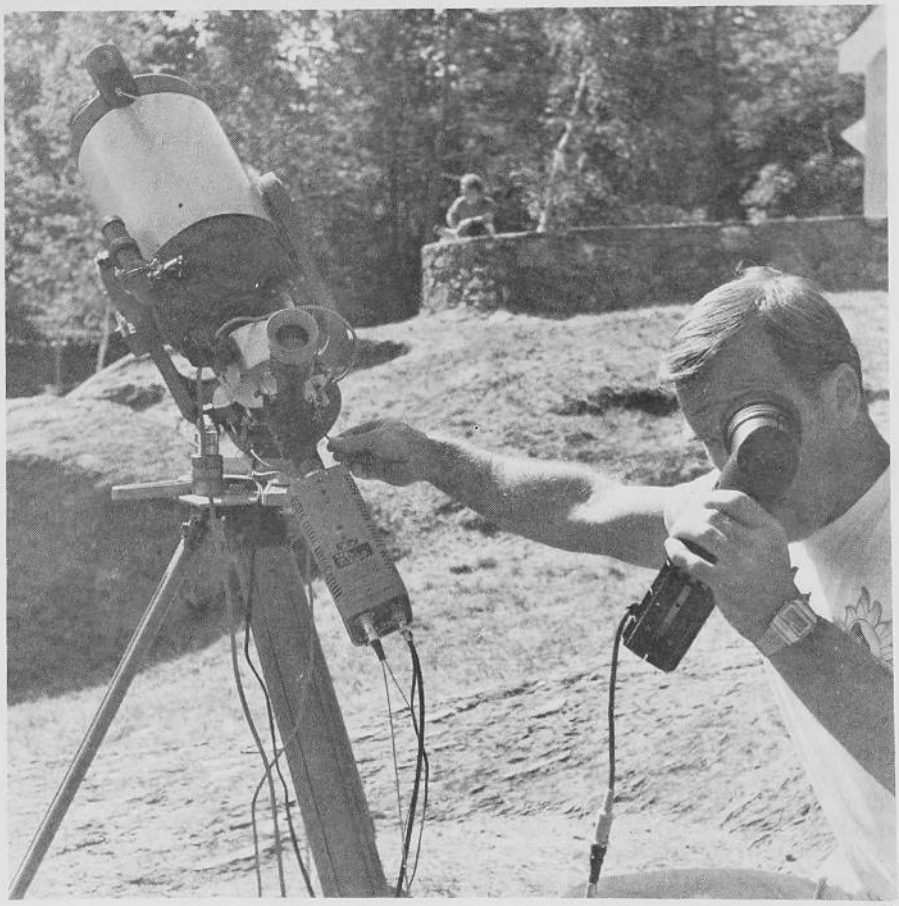
"You couldn't get glass over 10 to 12 inches back then, and if you could, the telescope you made with it was too big, too long, and too heavy. Well, in 1930, I had a 10", and in the 60s, I still had a 10". There was a 40-year plateau, a 40-year period of stagnation. That's ended now."

"I came up here and what did I see? One word: Dobsonians. They get around the shortcomings of the earlier big telescopes. Number one, they have thin glass. Number two, the alt-azimuth mount means there's no counterweight, and you can put it in your car. Number three, all the fancy stuff has been replaced by Teflon. And they're good enough."

"This revolution makes trouble for me and my column. I have to talk about 14th and 15th magnitude galaxies. Well, that's okay. But Dobsonians are going to hurt the telescope makers. They've been running in a 40-year rut. I'd guess that in ten years, if you buy a telescope, it'll be a Dobsonian."

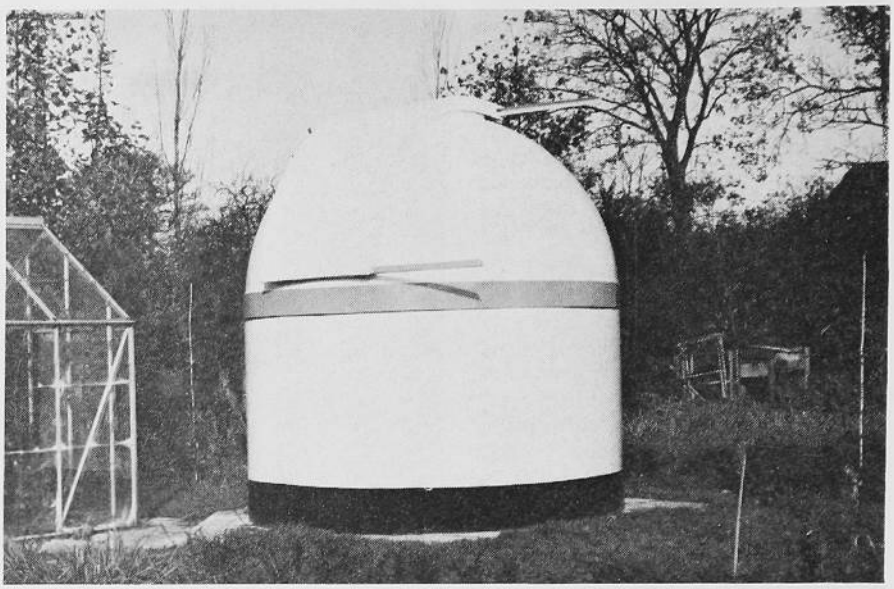
"This night will be remembered for perhaps a century or so. There are lots of these new telescopes on the hill. The surfboard is on the top of the wave, and you can go anywhere you want to go with it. Now I'll let that sink in. You've been a good audience."

— Walter Scott Houston



Steve Dodson, who last year impressed us with the "four axis" mount for his 22" f/7 thin-mirror reflector, shows its new Hammond cam drive (S&T, June 78) using a 3/4" threaded rod and a powerful little DC motor.

A Glass Fiber Observatory



The observatory, which I constructed almost entirely of fiber glass, is of the traditional arrangement with a hemispherical rotating dome on vertical side walls. It is nine feet in diameter with five-feet high walls and is to house my 12.5-inch Newtonian reflector.

Probably the most novel feature is the system by which the dome revolves. I overcame the problem of making a circular track, usually rolled from steel angle, by casting a fiber glass ring track with a double "ell" profile and attaching it to the dome rather than to the side walls.

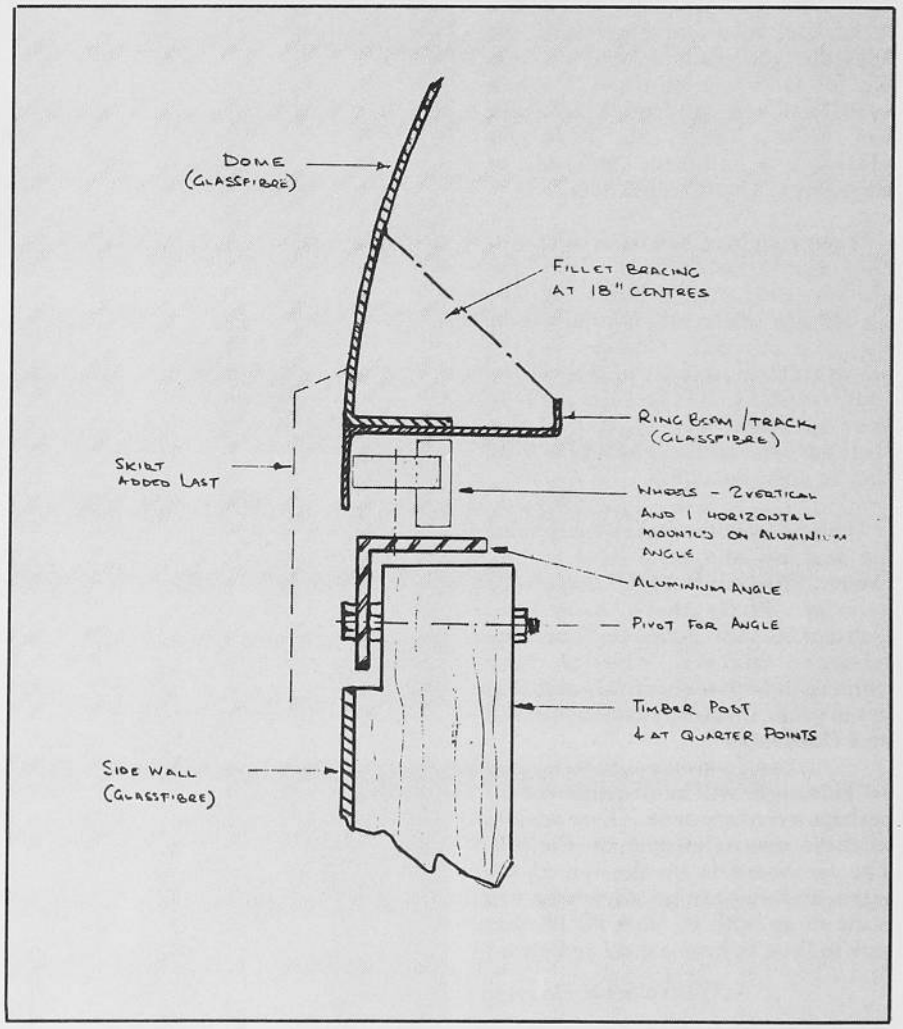
The dome comprises four identical quarter hemisphere segments initially assembled without a slot. The mold on which the quadrants were cast was made with lumber ribs, chicken wire (a fine wire mesh), and plaster to provide the double curvature. Note that a quarter hemisphere has three identical sides with three right angle corners and is therefore the easiest segment for which to build a mold.

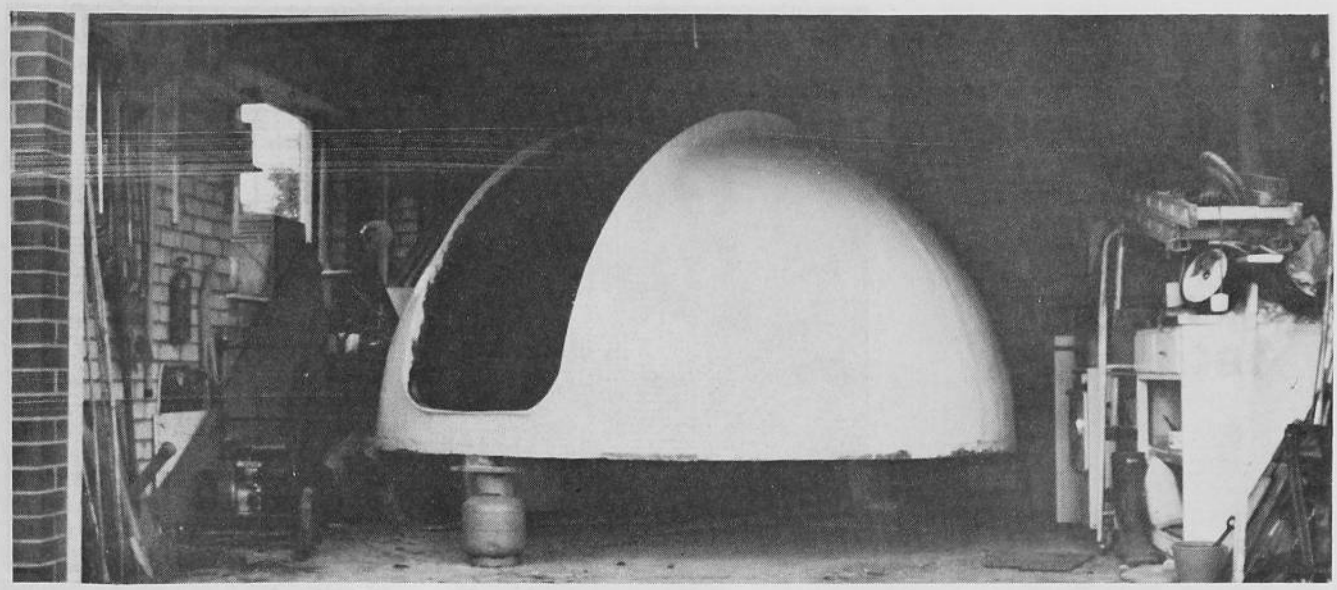
Each quadrant was cast with a lip on each edge which projects into the dome. These provide an easy way of joining the panels as well as adding considerable strength.

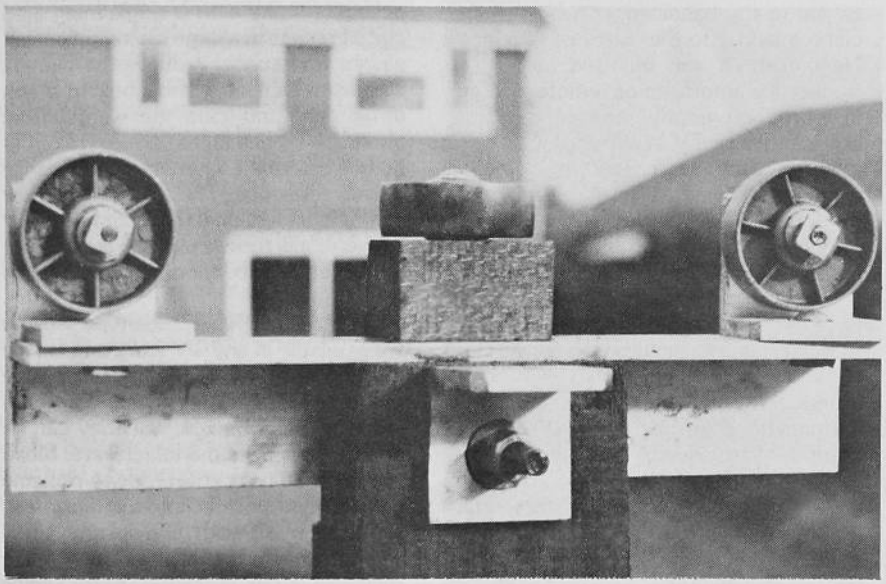
The ring track beam was cast, also in four sections, on a lumber and hardboard mold to the correct radius — see the drawing for its cross-section. Six pieces were actually made on this mold, the two extras being used later to strengthen the edges of the dome slot.

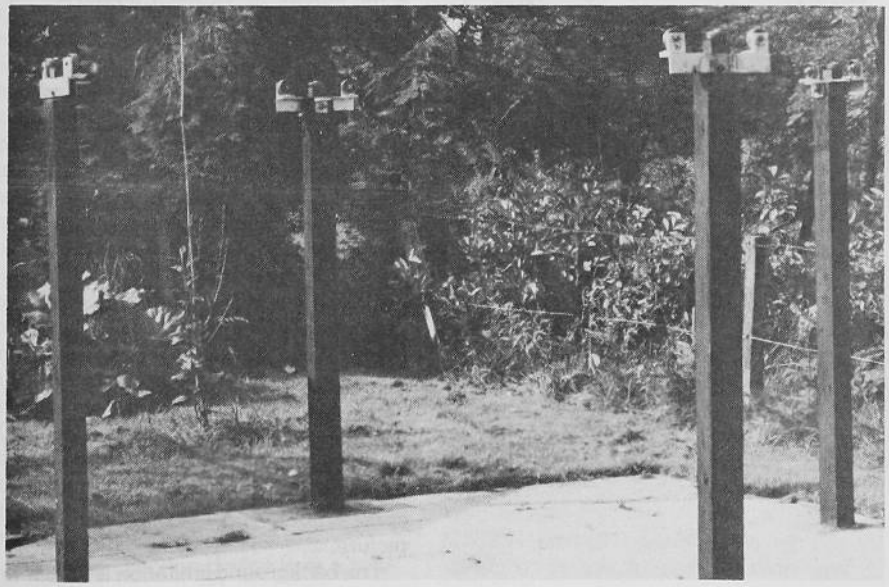
The four track beam segments were first assembled, leveled and checked for circularity, then simply butt-jointed with fiber glass tape. Next, the dome quadrants were placed on the ring beam and the joints flashed over with plenty of fiber glass. Joints between dome quadrants were staggered with respect to the joints in the ring beam.

The slot was then marked out and cut with a jigsaw. The two long sides of the opening were strengthened with the extra ring beam segments, providing a 4" upstand. The upstand around the rest of the slot periphery was completed *in situ* with fiber glass cast on temporary hardboard forms. A further layer of fiber glass cloth was added to the assembled dome and finished with two coats of white resin.









The slot is covered with a single sideways sliding cover. It runs on steel angles which I rescued from an old bedframe. The cover was cast on a mold made from timber and hardboard to the correct radius. As it is constructed of fiber glass, it is very light and does not alter the balance of the dome when opened.

The dome rests and turns on four-wheel suspension groups. These groups comprise three 2″ diameter wheels mounted on an aluminum angle on top of a vertical timber post. The posts are concreted into the ground. Each wheel group has two vertical wheels to support the dome and one horizontal wheel to provide lateral restraint. The aluminum angles carrying the wheel are attached to the posts with a single bolt providing a pivot so that loads in the two vertical wheels are equalized. An advantage of this system is that the side walls are non-load-bearing and therefore do not have to be particularly strong or accurately aligned.

The side walls are made of eight fiber glass panels cast on a curved mould. After making them, I noticed there was sufficient flex in the panels that flat ones could probably have been suitable. One of the wall panels was braced on the inside and forms the door. Once the walls were in place, a skirt, in a contrasting color, was added to the dome to cover the wall-dome gap.

The result, as I hope the photographs show, is an aesthetically pleasing observatory. I am hopeful that it will be free of maintenance problems such as leaking joints or warping panels.

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Adlington, Chorley,
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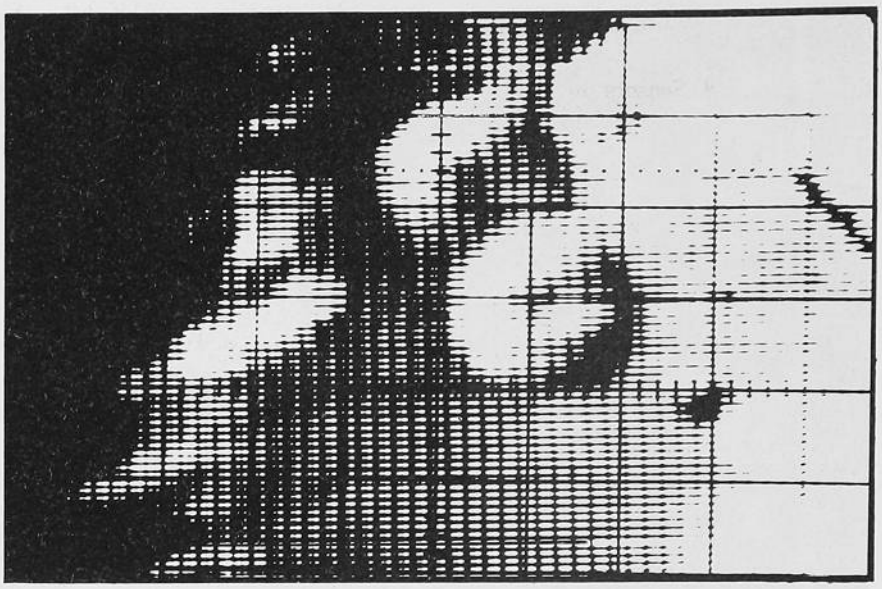
A Solid-State TV Camera for Amateur Astronomy



The state of the art in electro-optical technology has progressed to the point where sophisticated devices are now available to the amateur astronomer. A key element in this new field is the rapid decrease in the cost of electronics of a given complexity, and the broad technological base in electronics and electro-optics implies that there are many hobby astronomers capable of designing and operating advanced sensors and electronic devices.

Historically, new technologies have aided astronomy — first with measuring circles, then with telescopes, photography, photomultipliers, computers, and now solid-state detectors. But the mere existence of a new piece of technology does not mean it will be used — there must be some advantage in using the new device in terms of cost, sensitivity, accuracy, etc., otherwise the new technology is mere gimmickry.

Television on a telescope can serve well for public viewing (since more than one person can view at one time) and as an aid to the handicapped who cannot climb a ladder to the eyepiece of a long Newtonian. It can be used as a star tracker for automatic or remote guiding in astrophotography, one of the first applications of TV in astronomy. It can also be used as a wide-angle multi-element photometer for measuring star brightness. The widest use to date of TV in amateur astronomy has been for general viewing and public viewing.

The majority of TV experimenters have used tube-type TV cameras similar to those made for home video recorders. Recently a new type of TV sensor, composed of a single silicon or germanium chip, has appeared on the market. The device is actually an integrated circuit with an array of photodiodes formed on its surface. The diode array acts as a TV sensor and replaces the glass vacuum image tube (usually a vidicon) in conventional TV cameras.

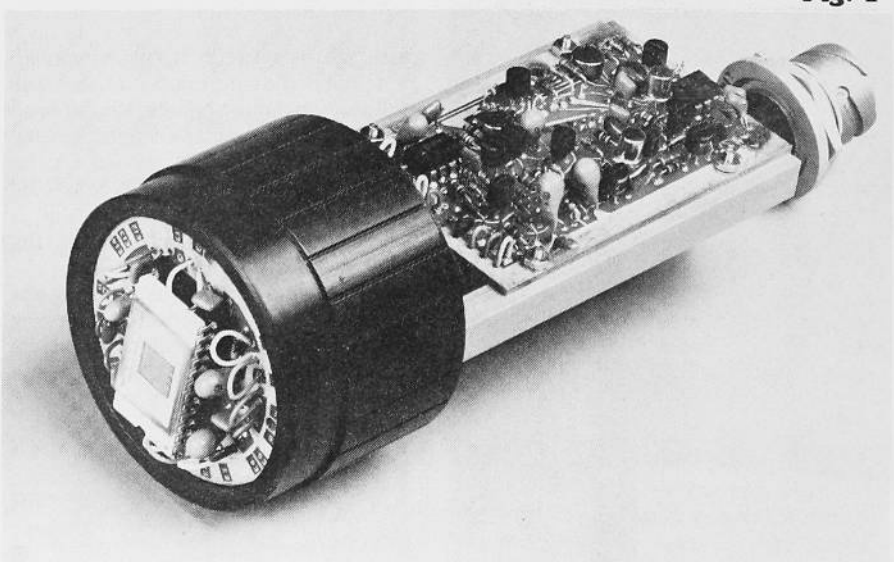


Fig. 1

Replacing the tube and magnetic deflection yoke with a single integrated circuit results in a large savings in power, weight and space, reduces the camera size from that of a shoe box to a soft drink can, and cuts the weight from about 1.6 kg (3.5 lb) to 0.37 kg (13 oz) — quite a difference when trying to balance a small telescope. The solid-state sensor has an additional advantage over conventional tube sensors in that it is not as susceptible to "blooming" caused by bright stars.

On the other hand, tube-type sensors are available in any TV store and can be plugged into any TV set or video tape recorder. Solid-state sensors are not found in retail outlets, but they can be ordered from the manufacturers. Most, however, do not come ready-to-run, and must be incorporated into a camera head and integrated with a display system. The advantage is that the design of the system is left up to the purchaser and he is not limited to standard displays.

Solid-state sensors lend themselves easily to non-standard scan rates, integration for more sensitivity and interface with computer systems. Tube-type sensors can be operated at non-standard rates and with computers, but their adaptation is much more difficult than it is for solid-state sensors.

The greatest difference between tubes and solid-state sensors is in the allowable integration time. Integrating starlight on the solid-state sensor increases sensitivity to faint objects in a manner similar to increased exposure times in photography. The integration is limited, however, by background, blooming, thermal noise and image spread. Given a long integration, a bright star may integrate to such a large signal that it spreads out and swamps the entire picture.

The background limitation is similar to

that found in films where the overall background light integrates until a "sky fog" is produced. Sensors with a large dynamic range will be able to see signals above this sky fog and can accommodate more sky fog without being swamped with signal.

Thermal noise is unique to electronic sensors and has no analog in films. It is a signal, much like background fog, which is produced by electron-hole pair generation in the sensor due to thermal action (heat). It can be reduced by cooling the sensor to dry ice temperatures.

Image spread is related to blooming but refers to star signals which are not saturated. The image of faint stars may tend to spread during a long integration. This is due to a slight conduction between picture elements. The effect produced looks like a defocused star image. Solid-state sensors, in general, outperform tube-type sensors in terms of background, blooming, thermal noise and image spread.

There are, however, a few tubes such as the Westinghouse deep-etched metal-capped SIT vidicons which have been specifically designed for stellar work and will have better blooming and image spread characteristics. These tubes cost tens of thousands of dollars and are typically produced as one-off items.

Solid-state sensors may be grouped into two broad categories: scanned externally and internally scanned. The externally scanned sensors have one wire for each photodiode in the sensor array. While this makes for relatively simple circuitry on the sensor chip, the external connections and switching become cumbersome when there are more than a few photodiodes.

Internally scanned, or self-scanned, arrays typically have only one output line and several inputs which command the chip to look at different photodiodes and report the amount of light striking the selected one. Of the self-scanned arrays, two broad categories again emerge: the charge injection device, or CID, and the charge coupled device, or CCD. Both use an array of silicon photodiodes to sense light and both use a storage mechanism (usually a capacitor) at each pixel (picture element) to integrate the total amount of light striking a pixel from one readout to the next. The differences between the two arise from the manner in which data are taken from each pixel and directed to an output amplifier located at the edge of the sensor chip. The CCD passes minute packets of charge from pixel to pixel along a line — much like a bucket brigade. At the end of the line is a switch directing each line's output to the video amplifier.

A charge injection device uses a row-column switch matrix to transfer charge (signal) from the designated pixel into a substrate conductor which underlies the whole sensor. This substrate is connected to the video amplifier.

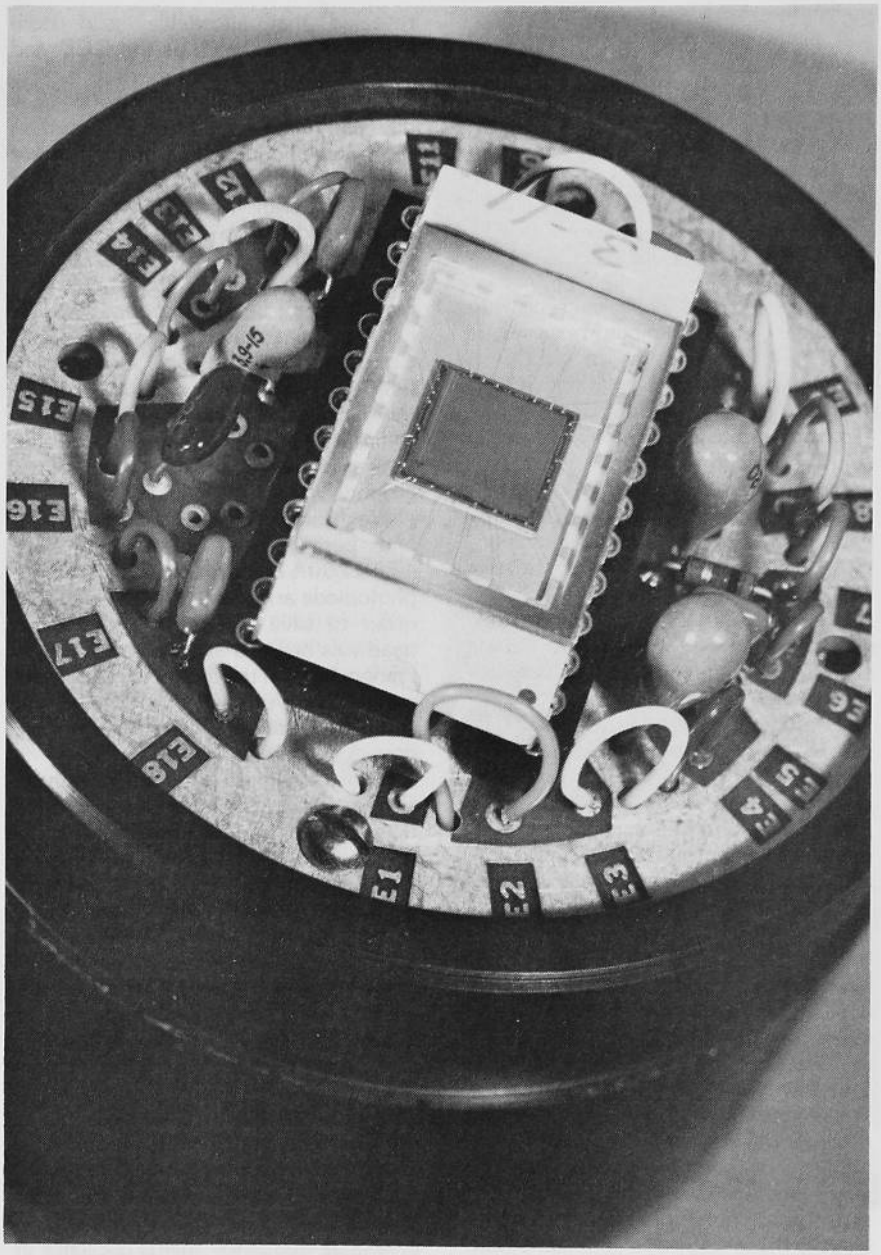
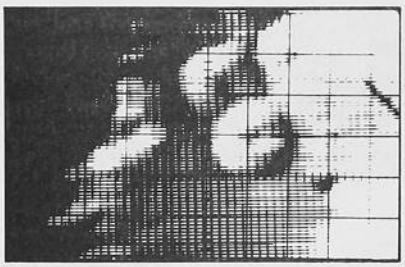


Fig. 2: *The 4TN2200A1 camera head. Photo courtesy General Electric Co.*

From the point of view of the user, both types of sensor are functionally identical. Both sample the photodiodes — and the differences are all internal with one exception. CCD sensors require charge transfer lines running along the rows of pixels on the surface of the chip. These lines are not sensitive to light. Light falling on these lines is therefore not sensed. For most normal scenes of extended area subjects, this defect is not apparent, but for astronomical use, stars can "fall into the cracks" between pixels.

CCD charge transfer lines vary in width according to manufacturer and chip model, but they typically cover to half the area of the array. Several years ago I performed experiments with a Fairchild CCD 211 array in which a star was imaged and then the sidereal drive was turned off. As a star moved across the array, it alternately appeared and disappeared as its image fell first on the sensitive pixels and then on the insensitive charge transfer lines. This defect was a prime reason I chose a CID array over a CCD for the present camera.

One method of overcoming this defect is to place the CCD array inside an image intensifier bottle in place of the output phosphor. The array is then struck by electrons from the photoemissive surface rather than directly by photons. The entire CCD array is sensitive to



electrons, so the gaps in sensitivity disappear. This technique, however, is extremely expensive. In addition, preliminary results indicate that the array suffers soft X-ray damage from the electrons striking it and will eventually cease to function.

In terms of resolution and sensitivity, the major manufacturers of CCD and CID offer more resolution for more money and are generally competitive in cost for a given resolution or sensitivity. CID devices offer slightly longer possible integration times and therefore have a slight advantage for use under very low light levels.

One characteristic of CCD and CID sensors involves blemishes: individual photodiodes which, for various reasons, do not match the rest of the photodiodes in sensitivity and noise. Such blemishes are usually manufacturing defects. There are "hard" and "soft" blemishes. The most common type of hard blemish is a shorted photodiode — which results in the pixel being on (bright), no matter what the optical input. For astronomical applications, such a pixel appears as an extra star, a nuisance but not an unsolvable problem. It does not move on the display when the telescope is moved. A less common hard blemish is a dead, or open, diode which results in a dark pixel. Similarly, there are soft blemishes in which diodes are significantly less sensitive but not totally shorted or open. Usually these show as a faint star or dim patch.

After looking at many CCD and CID sensors, I've found that one manufacturer's soft blemish is another manufacturer's good device. Typically, the CID devices have fewer blemishes and those that appear are of the soft variety.

A Little History

My current TV camera design came about as a result of a cooperative effort by a group of amateurs who belong to the San Jose Astronomical Association. Our original goal was to devise a two-axis star tracker to guide the telescope during long exposures. Since San Jose is located in a center of electronics technology development (often referred to as "Silicon Gulch"), many club members were experienced in electronics design. A discussion of possible sensors and a little research revealed that affordable solid state imaging devices such as the CCD and CID photodiode arrays existed.

We soon realized that these devices offered greater spatial resolutions than the conventional quadrant tracker we originally contemplated. This, coupled with the possibility of a TV-type display, encouraged us to look at additional applications — such as public demonstrations and star brightness measurements. Funding for the first camera head came from the IBM Corporation Fund for Community Service in the form of a $1,000 grant to the San Jose Astronomical Association. Without this generous support the project would have never gotten off the ground.

We decided, based on cost, availability and performance, to use the GE 4TN2200A1 camera head. The photodiode array is 128 by 128 pixels. In order to save money, a bare camera head was ordered and work was begun immediately on the design of the camera control unit consisting of the power supplies, scan rate generator, display drivers and display.

Before designing the camera control system, the club members were polled to determine their needs and observational requirements in terms of camera performance. An attempt was made to design a system which would allow operation over a wide range of conditions in all types of observations and be rugged, portable and easy to use.

The initial camera control design (figure 3) called for a variable readout rate, or variable scan rate, allowing us to use a wide variety of integration times. This implied a variable clock rate input to the camera head. We decided to implement this by using a fixed frequency crystal controlled oscillator and digital count-down chain rather than a variable frequency analog oscillator in order to have the requisite camera stability for precision measurements. Digital camera control, merely convenient in the early stages of system development, would become important in the later stages of system development when computer interface and control of the camera were implemented. The readout rate control allows for a selection of scan rates between 35.4 msec per frame and 3.54 seconds per frame.

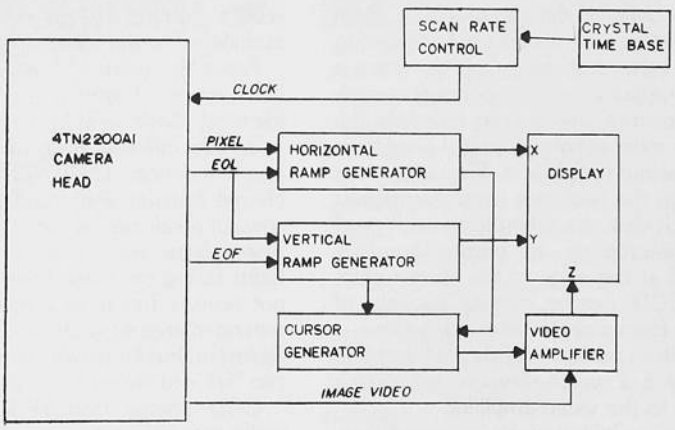
The digital controls also facilitated control of the display generator subsystem. In previous variable rate TV systems I've worked with, a change of scan rate in the sensor head necessitated a change of scan rate controls in the display subsystem. In the present system, the display generator tracks the scan rate in the sensor head and automatically adjusts to any new scan rate commanded by the timing control subsystem.

Initially, a simple X-Y-Z oscilloscope was used to display the sensor head output in real time. This implies that at slow scan rates the display flickers, an inconvenience that can be tolerated until better displays can be developed and interfaced. We are now developing a digital scan converter that will refresh a standard TV display.

An open crosshair cursor can be generated electronically at any position on the screen. This pointer is valuable when using the camera for guiding photos and may prove useful as a pointing device when the computer interface is completed. The position of the cursor is controlled by a set of thumbwheel switches.

The overall camera design emphasized rugged construction and portability. Although it was designed to run off of 115 VAC, we selected power supplies operable from square wave inverters so that 12 VDC power could be

Fig. 3: *System Block Diagram*



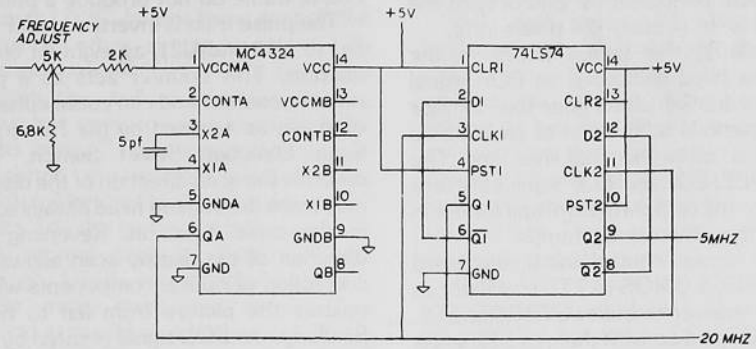


Fig. 4: *An alternate design for an oscillator*

used in the field. We selected components from retail hobby electronics stores in order to keep costs down and to enable other amateurs to build systems based on the design. Finally, we kept the system documentation as clear and complete as possible to enable others to use the data.

Theory of Operation

The CID camera head, shown in figure 2, is composed of a sensor chip, readout control electronics and video amplifier. The sensor chip, shown in figure 3, is composed of an array of 16,384 individual picture elements in a 128 by 128 format. Each picture element consists of a silicon photodiode and a capacitor. Light falling on the photodiode causes the capacitor to charge. The amount of charge is proportional to the light intensity and the time the charge is allowed to accumulate.

Electrodes are arranged horizontally and vertically in rows and columns across the face of the sensor. Each row and column electrode may be activated separately. Activation of a pair of row-column electrodes causes the pixel at the intersection to dump the charge stored in the capacitor into the conductive substrate. This charge is sensed by an on-chip buffer amplifier and its output is sampled and latched after the injection pulse and before the next pixel is addressed.

By sequentially accessing adjacent pixels in a row, one row after another, we can make a raster sampling of the entire 16,384 pixels. This is the basis of the TV-like display. While this application uses a raster scan, it is possible to access pixels in any desired order. GE has developed a system called Random Access Charge Injection Device (RACID) which performs this function. Display of a conventional image using this system would be difficult, but it does have some applications in computer image processing.

The circuitry that controls the sequencing of the row and column lines in the current camera is all contained on the sensor board and in the sensor chip. Control of the charge injection which causes the dumping of the capacitor is accomplished on the timing board; similarly, the output latch is controlled from the timing board. The actual latch of the output and video amplification is on the video board. The sensor board, timing board and video board are all mounted in the camera head as shown in figure 1. These are supplied by Ge with the camera head. The rest of the camera system was designed and built from scratch.

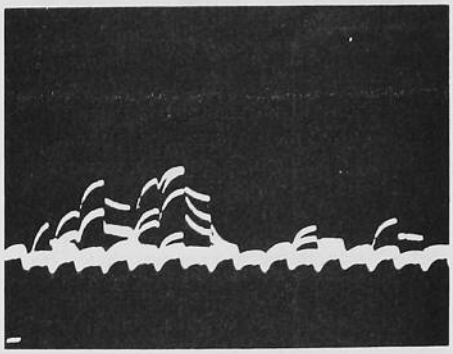
Camera Control Unit Timing Board

The camera control unit timing board should not be confused with the camera head timing board already described. The camera control unit timing board has two functions: it sets the scan rate and develops the ramp voltages required to drive the display. The scan rate is developed from a crystal controlled oscillator which puts out 20 MHz and 5 MHz TTL square waves. This is usually an expensive chip, but I found mine in some surplus military electronics. You may replace it with the circuit shown in figure 4 which drifts slightly in frequency when the temperature varies, although it can be adjusted to compensate. The lack of absolute accuracy in the time base does not degrade camera system performance — but it would make frame-to-frame correlation of event times difficult if the camera were used for computer-reduced occultation timing.

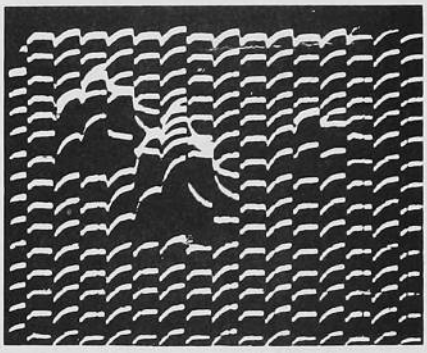
For the following discussion of the circuit, refer to the drawing "CID Camera Control Unit Timing Board." The 20 MHz master clock signal is buffered in U7F and fed to U6 and U3. These modulo-n dividers divide the 20 MHz into lesser frequencies as commanded by the rate select switches. The rate select switches are implemented as four hexadecimal thumbwheel switches mounted on the edge of the timing board. U7E and U2A are used to reset counters U6 and U3 at the end of each countdown cycle. The output of U2A is a non-symmetrical pulse at the end of each countdown cycle. It is converted to a square wave with a 50 percent duty cycle by U5, a D flip-flop. The D flip-flop also divides the frequency by two. Its output is the camera clock frequency. It is buffered by U8A, U8B, and U8C which also convert it to CMOS signal levels before being sent to the camera head. A single 74128 can replace these three buffers — but 74128 chips are not easily obtained.

The clock output is sent to the camera

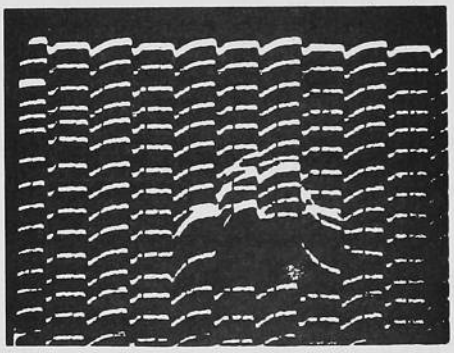
Fig. 5: *Oscilloscope displays from CID camera, no intensifier, star scene simulator.*



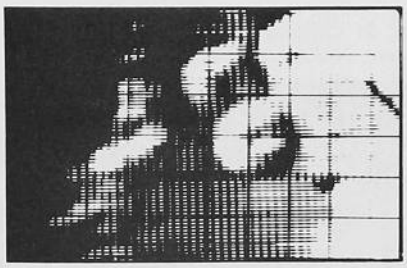
Three Stars, Conventional Display



Three Stars, Pseudo 3D Display



Single Star Covering 16 Pixels



head and is used to develop the read-timing signals for the sensor chip. The clock frequency may vary from 50 KHz to 3.5 MHz at the user's discretion, corresponding to a frame time from 28.3 to 0.283 frames per second. The timing board in the camera head takes the clock and divides it by ten to obtain the STROBE signal. This signal indicates that a new pixel is being read out each time it goes low. The timing board in the camera head also generates an EOL signal (end of line) which goes low for 6 STROBE periods at the end of each line which is, of course, 128 pixels long.

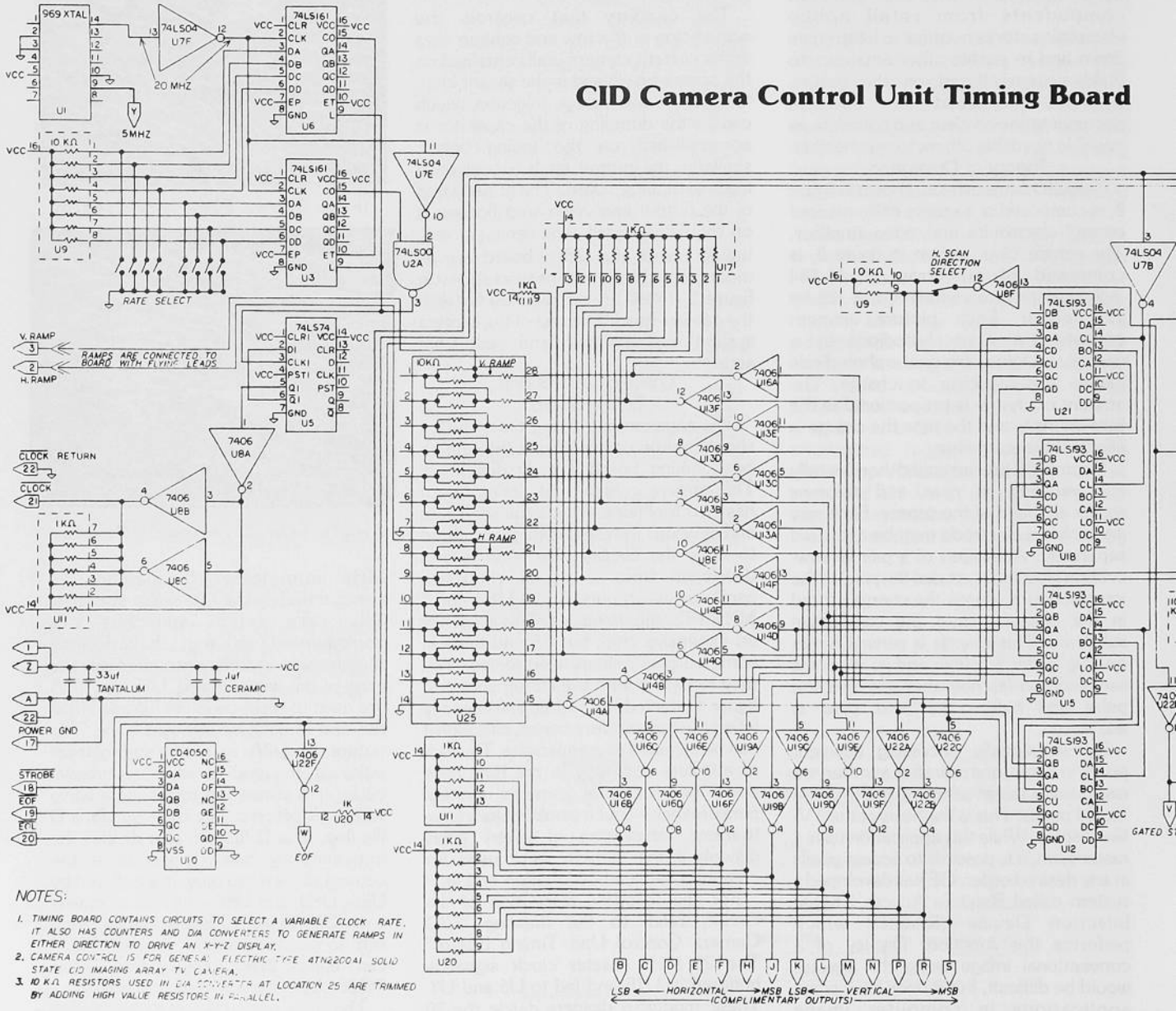
Similarly, the timing board in the camera head generates an EOF signal (end of frame) which goes low for four EOL periods at the end of each frame which is, of course, 128 lines long. The STROBE, EOL and EOF signals are sent back to the camera control unit for use in developing the display ramps.

The camera control unit timing board uses U10, a CMOS to TTL translator as a line receiver to buffer STROBE, EOL and EOF and convert them to TTL levels used on the rest of the board. U22F is used to buffer the EOF signal which is sent to other circuit boards within the camera control unit. The STROBE signal is gated by EOF and EOL via U2B, U7C and U2C to form a pulse train which corresponds only to active pixels. The inactive pixels during the end of line and end of frame do not produce a pulse.

The pulse train is inverted in U8F and fed to U18 and U21, an eight-bit binary counter. This counter acts as a pixel number counter and can count either up or down as selected by the Horizontal Scan Direction Select Switch. This controls the scan direction of the display only since the camera head always scans in the same direction. Reversing the direction of the display scan allows for correction of optical components which reverse the picture from left to right. Similarly, the EOL signal is gated by the EOF signal, inverted in U8D and fed to U15 and U12 which is an 8-bit binary counter which counts the line number.

The line counter can also count either up or down, allowing correction for optical components which reverse the

CID Camera Control Unit Timing Board



NOTES:

1. TIMING BOARD CONTAINS CIRCUITS TO SELECT A VARIABLE CLOCK RATE. IT ALSO HAS COUNTERS AND D/A CONVERTERS TO GENERATE RAMPS IN EITHER DIRECTION TO DRIVE AN X-Y-Z DISPLAY.
2. CAMERA CONTROL IS FOR GENESA ELECTRIC TYPE 4TN2200A1 SOLID STATE CID IMAGING ARRAY TV CAMERA.
3. 10 KΩ RESISTORS USED IN D/A CONVERTER AT LOCATION 25 ARE TRIMMED BY ADDING HIGH VALUE RESISTORS IN PARALLEL.

image from top to bottom. The pixel counter and the line counter outputs are buffered by an array of buffers, U16B through U22C, before being sent off the board to other circuit boards in the camera control unit. U20 and U11 contain the pull-up resistors for the active low open collector outputs of the buffer array. The complimentary outputs constitute the current pixel number which will be used by the pixel designator board and the computer interface.

A second array of buffers, U16A through U14A, is paralleled with the buffer array mentioned above. This second array drives an array of resistors mounted on U25 which constitutes a 2-R-2 ladder array. This ladder resistor network derives a summation voltage proportional to the binary values in the buffer array and therefore is a D/A converter. The array is divided into two ladders, each of which is seven bits long. These ladders produce horizontal and vertical ramps for driving the display. The ramps will be either increasing or decreasing ramps depending on the position of the vertical and horizontal scan direction select switches. The second array of buffers and ladder resistor network could be eliminated by replacing them with a D/A converter chip such as the DAC-O8B — but this would be considerably more expensive.

The final components on the camera control unit timing board are the buffers generating the gated strobe, U22E and the gated end of line, U22D. If the system does not include either a pixel designator board or a computer interface, then the output buffers to the card edge, pins B through S, are not needed. The pull-up resistors on these lines would not be needed either.

Pixel Designator Board

The pixel designator board performs three functions: it generates a movable open crosshair superimposed on the picture, it generates an output pulse to the computer whenever the data from the designated pixel is on the video lines, and it generates a vertical ramp over the area of the crosshair for aid in diagnostic displays.

The designated pixel is, of course, at the center of the crosshair. The crosshair is open so that a star may sit at the center and not be covered by the crosshair. If you do not want a crosshair and the computer interface does not require a designated pixel, then this card may be eliminated entirely without affecting system performance.

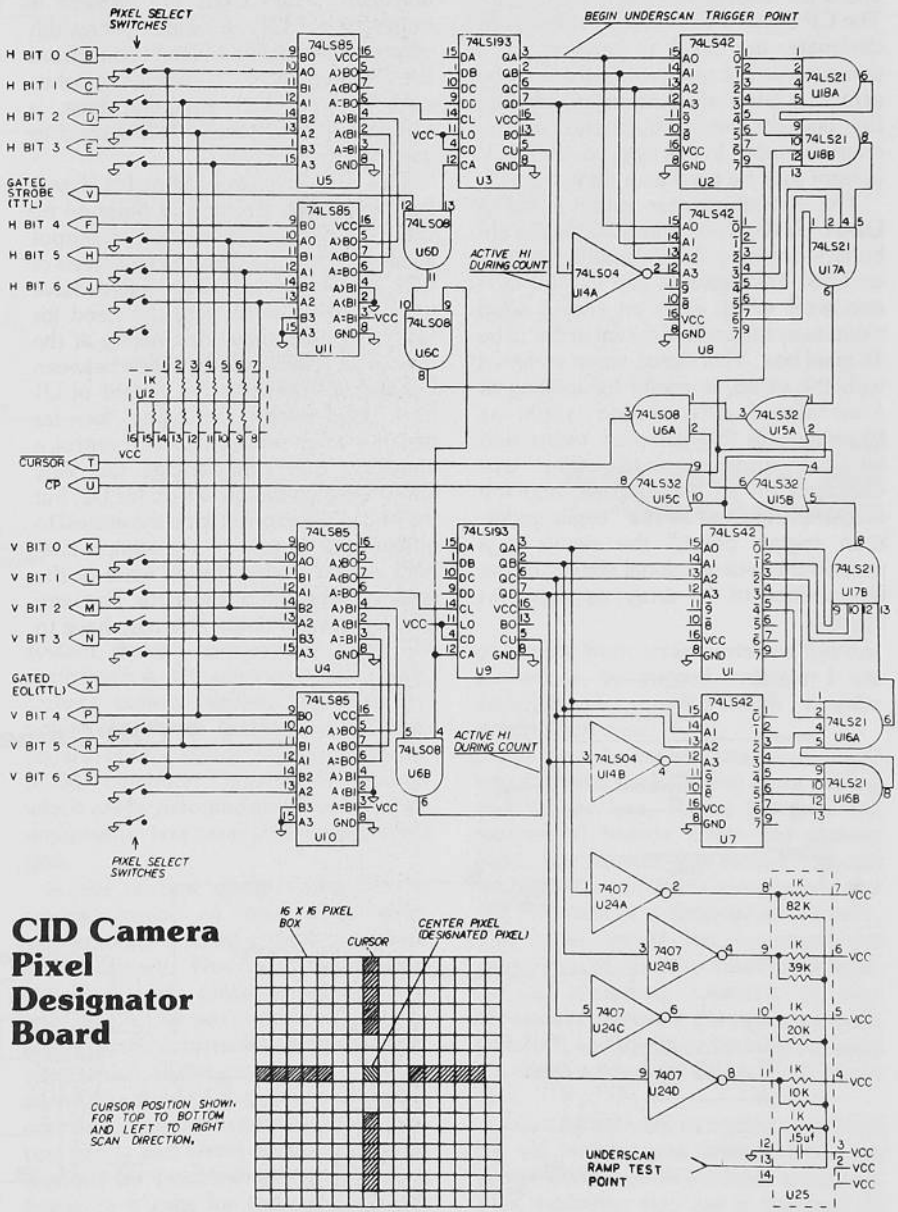
The current pixel number (horizontal and vertical position of the scan point) are transmitted from the timing board via card edge connector pins B through S. These data are read into U5, U11, U4 and U10 which are four-bit comparators. The pixel select switches are implemented as four thumbwheel switches, each handling four bits.

The data from the thumbwheel switches are also fed to the four comparators for comparison with the current pixel number. When a match is detected between the current pixel number and the pixel select switches, pins 6 of U4 and U5 go high, clearing the horizontal and vertical four-bit counters, U3 and U9. These counters define the box enclosing the cursor.

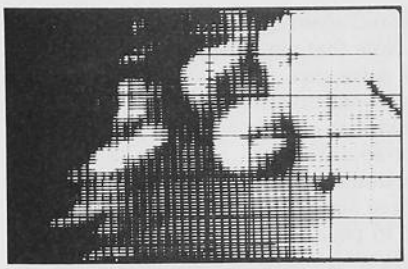
When U3 and U9 are cleared, the carry outputs (pin 12) on both counters go high and are fed to U6D and U6B. These gates allow the gated STROBE and gated EOL to drive the counters until a count of 15 (F in hexadecimal) is reached, at which time the carry outputs go low and inhibit count pulses from reaching the counters until they are cleared again by the comparators.

Note that the upper counter input has an extra gate, U6C, which inhibits the horizontal counter from activating when there is a match between the current horizontal pixel number and the horizontal, but no match in the vertical. These two counters therefore define a 16 by 16 pixel area on the display screen. Assuming a top to bottom and left to right scan, the pixel select switches define the upper left pixel in the box. The open cursor is drawn, and the underscanned ramp formed, within this 16 by 16 pixel box.

The outputs of the counters are fed to U2, U8, U1 and U11 which are one-of-eight decoders. By inverting the most significant bit and feeding the lower decoder of each pair, U2, U14A and U8 become a one-of-sixteen decoder and U1, U14B and U7 become another one-



CID Camera Pixel Designator Board



of-sixteen decoder. The outputs of the one-of-sixteen decoders are low for one line or one row of the 16 by 16 pixel box. The logic array formed by U6A, U15A, U15B, U15C, U16A, U16B, U17A, U17B, U18A and U18B generates two signals, one of which is low during pixels on the open crosshair and the other of which is low during the center pixel. See the schematic for an illustration of the pixels affected.

The CURSOR signal is fed to the video board for mixing with the video output. The CP signal is sent to the computer to designate the pixel of interest. If a computer is not used, this signal may be sent to a latch which samples video on that pixel for output to a meter or strip-chart recorder. In this way, your CID TV system may be used as a photometer.

The vertical counter output is fed to U24A, U24B, U24C and U24D which are buffers driving a 2-R-2 resistor network on U25. The network is a four-bit D/A converter which gives an analog ramp signal over the vertical extent of the 16 by 16 pixel box. This signal, when summed with the video, is useful for looking at area-related phenomena such as blooming. If the summed video and vertical underscanned ramp are displayed on an oscilloscope, and the scope is triggered at the "begin underscan trigger point," the result is a pseudo-three-dimensional display of the box portion of the array, as shown in figure 5.

Video Board

Two video boards have been designed for the camera control unit. The first is a simple two-stage amplifier designed to drive the cathode on most common oscilloscopes directly with a ±15V output swing. It is bandwidth-limited at the fastest scan rate available, but it performs well under most circumstances. With excessive video input it saturates and can lock up, or latch, either high or low in this condition. To correct this, the excessive optical input must be removed, the gain must be decreased, and the power must be turned off, then on again.

A more sophisticated video amplifier was therefore designed using costlier parts. It incorporates LED indicators which enable the operator to set the gain to within the limits acceptable to the A/D converter and the analog output amplifier. Video from the camera is buffered in U1, a wide bandwidth differential amplifier. Since the data from the camera have numerous glitches especially at pixel switching time, a sample-and-hold switch, U2, is used to gate out the glitches.

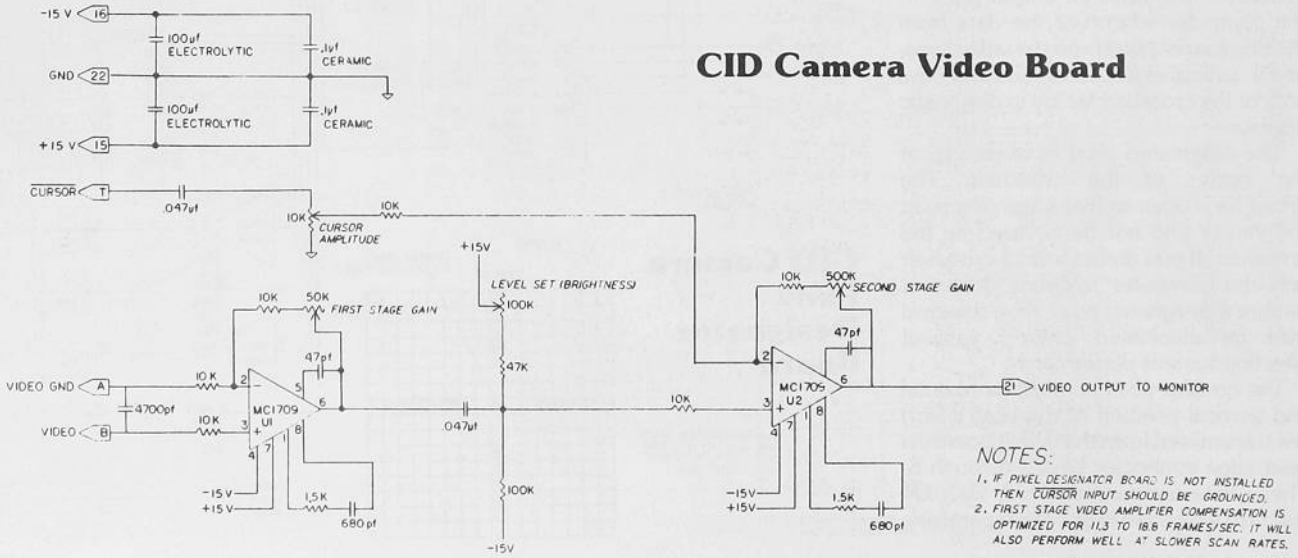
This is driven by a one-shot, U3, driven by the camera strobe and buffered by U4D. U4 also translates the TTL output levels of U3 to the CMOS input levels of U2. A CMOS one-shot might have worked here, eliminating the need for U4, but I didn't have one handy at the time. The 1N5895 clipper diode between U1 and U2 prevents the output of U1 from inadvertantly swinging too far negative when setting the level control, a condition that can damage U2. Any CMOS analog switch will do for U2, but the MC14529 appears to be the easiest to obtain. The output of the sample-and-hold is held during the off state of the switch by the 150 pf capacitor. For very long integration times, this may have to be increased since the pixel rate will be low and the capacitor voltage will drop between successive pixels.

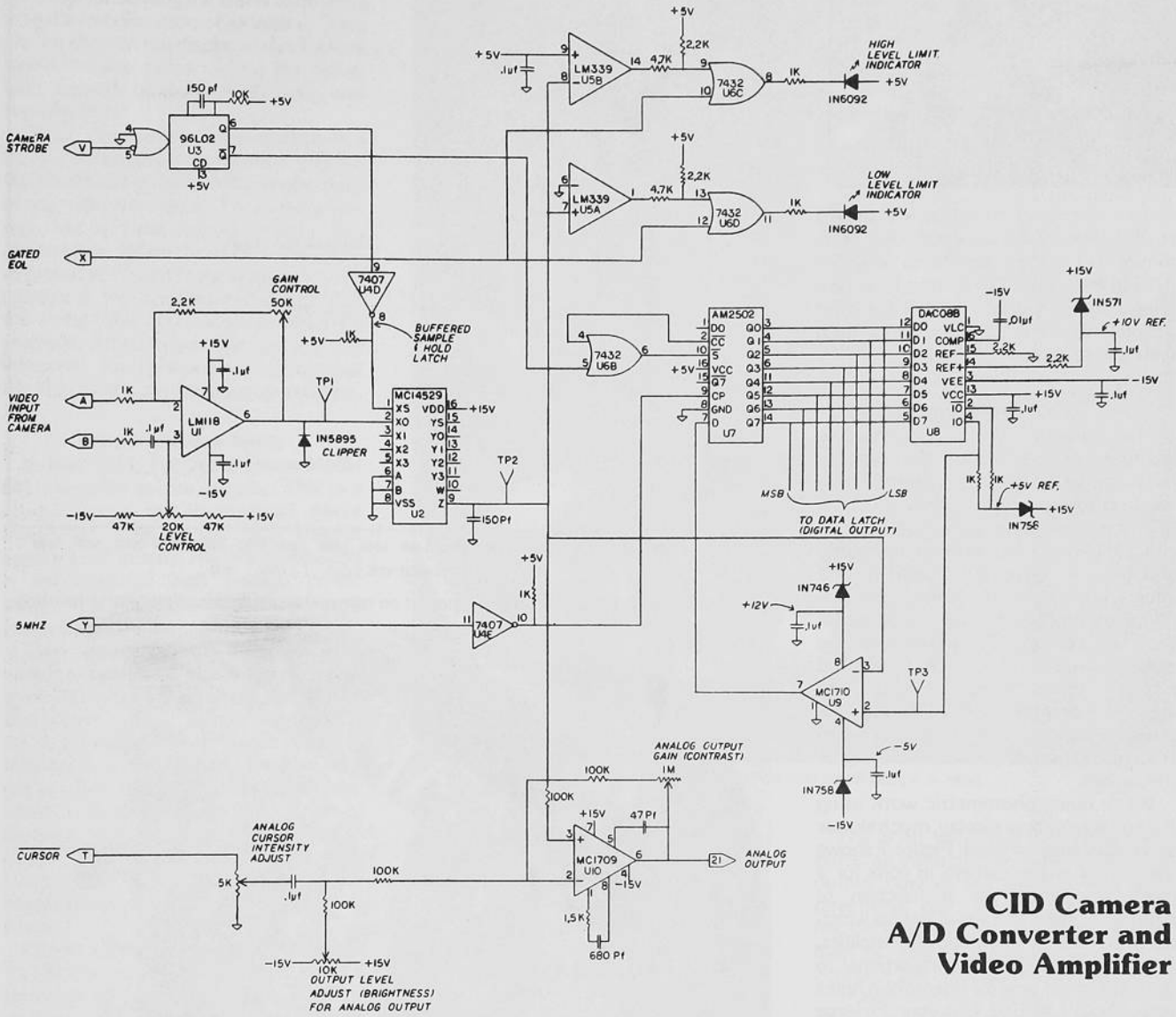
The output of the sample-and-hold goes three places: the analog output, the A/D converter, and the level indicators. The level indicators allow optimum setting of the gain and level controls on U1 while assuring that the levels do not exceed the A/D converter capabilities. The A/D converter can handle inputs between OV and 5V. The comparators put out a pulse if the input exceeds these limits. U6C and U6D gate the outputs to eliminate the saturated video at the end of each line. Their output drives LED indicators which light when the levels have been exceeded. The entire level indicator circuit may be deleted if the operator wishes to check the levels with an oscilloscope probe at test point TP2 each time a new object is viewed or each time the gain is changed.

The A/D converter, composed of U7, U8 and U9, uses the successive approximation register approach. Video analog data from the sample and hold, U2, are fed to a comparator, U9, and continuously compared with the output of the D/A converter, U8. The input to the D/A converter is from U7, the successive approximation register. Upon a positive pulse to pin 10 of U7, the successive approximation register attempts to match the input at U9 pin 3 by successively trying first the most significant bit, then the next most significant bit, etc. The output of the comparator, U9 pin 7, is fed back to the successive approximation register, U7, to control the output bits.

The 5 MHz input to U7 controls the clocking rate of U7. This rate is slow enough to allow the output of the successive approximation register to get through the D/A converter and the comparator for feedback to the register.

CID Camera Video Board





CID Camera A/D Converter and Video Amplifier

I have allowed 200 ns for this. The clocking rate is also fast enough for all eight bits to be generated within the time of one pixel.

It is also fast enough to do a full 8-bit conversion for all scan rates except the fastest one which is seldom used. The D/A converter circuit takes almost two microseconds to digitize a pixel, no matter what pixel rate is being used with the camera. Pin 2 of U7 signals that the conversion for a given pixel is complete. This signal may be used to control an output latch to the computer.

The final section of this board is the analog output amplifier. This supplies a ±15 volt analog signal suitable for direct drive of an oscilloscope cathode Z axis input. It is similar to the second stage of the earlier video board.

Mechanical Assembly

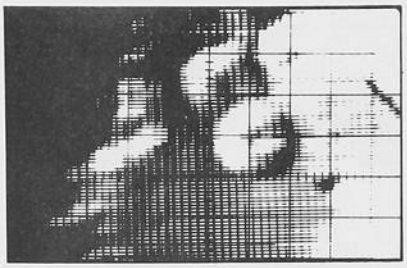
The mechanical design of such a system doesn't appreciably affect its performance. The original version of the camera control system was built on hobby electronics boards about 10 cm square, but the system is being rebuilt on S-100 computer compatible boards which will be mounted inside a .30 caliber ammunition box to provide a rugged field unit.

In the current design using 10 cm square cards, all card cage edge connectors are wired straight across to the next card. This facilitated reading schematics and following signals from one card to the next. Included, but not shown in the schematics, is an extender card which allows one card to be set above the level of the others while still connected via the extender. This allows test points and wiring on the card to be reached for troubleshooting. The open frame card cage for the current cards was made from scrap parts and has not proved to be rugged enough. I am switching to cards which fit the ammunition case.

Recently the camera head was rebuilt into a smaller package that is not as long and weighs less. Figure 6 shows the rearranged boards within the camera head. The camera now passes between the forks of a standard Celestron without the necessity of a diagonal attachment. The lower weight has increased the camera's usefulness for small telescopes.

The modified camera is not hermetically sealed in the new enclosure, however, so care must be taken to keep the camera head dry if conditions cause dew.

The original front mounting plate from the old housing was retained since the sensor board sits in the front mounting. This mounting also has a standard C-



mount thread which enables standard small lenses to be attached to it. A T-mount to C-mount adapter is generally used to mount the CID camera head on a telescope. A special 1.25" to C-mount adapter allows the camera to be used with any telescope.

System Performance

The camera system performance depends, of course, on the type of telescope used. All data presented here are from observations with a 20.32 cm (8") aperture telescope operated at either f/10 or f/5. The limiting magnitude and camera sensitivity depend on the integration time in much the same way that photographic sensitivity depends on the exposure time. The integration time is the time to sample all 16,384 pixels, and typically varies from 1/30-second to several seconds. When using the conventional-type TV display, a rapid scan rate is used to prevent flickering on the screen.

When doing photometric work using the voltage vs. time display, much slower scan rates may be used. Figure 7 shows the output of the camera in volts for a given star image as a function of integration time. For small signals which do not saturate the video preamplifier, the response is linearly proportional to the integration time for integration times up to about 1 second. However, for large signals and longer integration times, an increase in the integration time does not result in a corresponding increase in signal output.

This is due to two efects: first, the output amplifier on the CID chip saturates with large signals. Second, the image of strong point sources creates an excess of carriers in the diode array, and the charge migrates to adjoining pixels. This results in an apparently larger area for the star than the optical area of the image of the star. During tests on long integration times, it appeared that smaller, nonsaturated signals were still integrating linearly at longer integration times. These signals, however, are difficult to measure since they occur at intervals of several seconds.

These data were taken without the image intensifier. As a benchmark for comparing sensitivities with other systems, this system can sense a star of m_v =4.0 at 11 frames per second; the

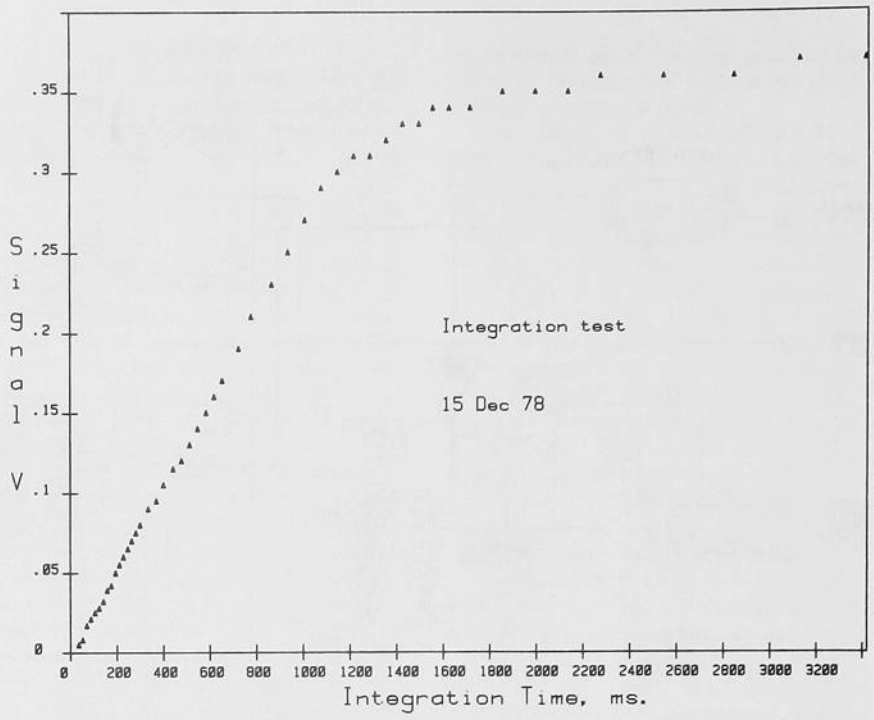


Fig. 7: *Integration test performed on star scene simulator without frame blanking*

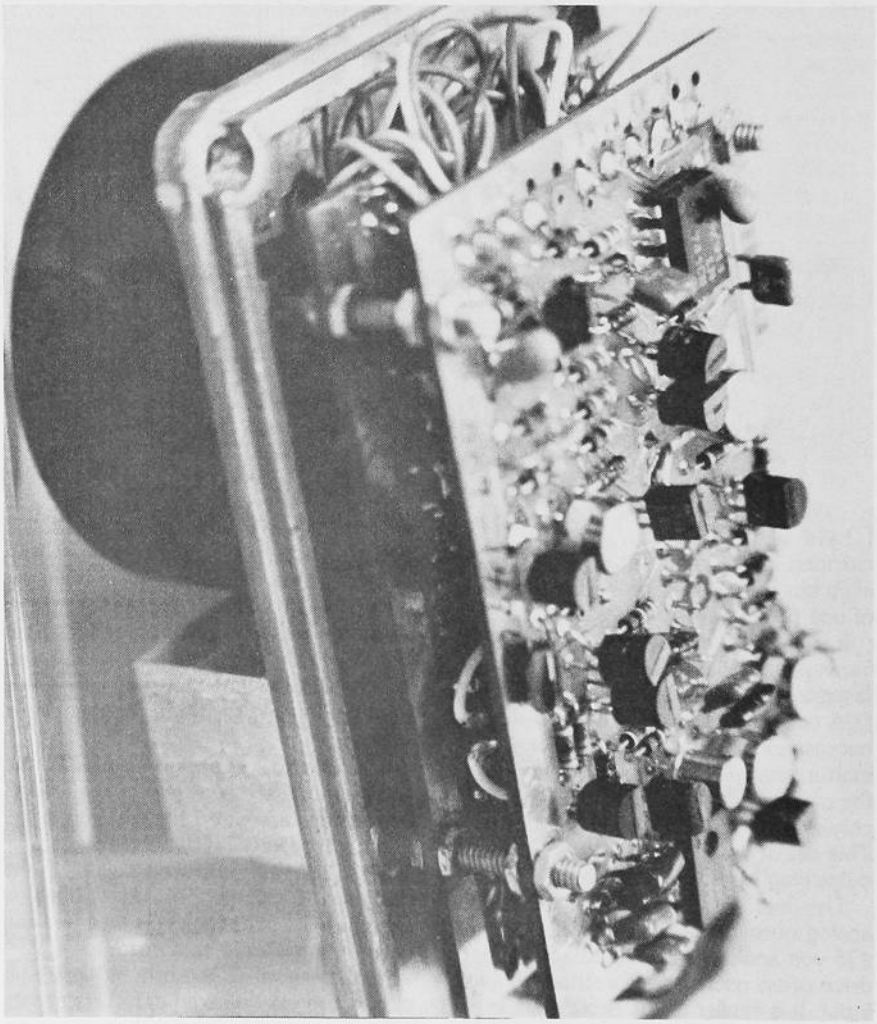


Fig. 6: *The rebuilt camera head is much more compact than the original packages.*

criterion for sensing the star is to observe a signal-to-noise ratio of at least 6. Stars can be seen on the display at much lower signal-to-noise ratios — but the actual limit depends on the type of display and the observer.

These observations were made with a 20.32 cm telescope operating at f/10 for the observation under fairly bright skies of $m_v = 16.0/(\text{arc-sec})^2$. The camera was not background-limited during the observation. When the same telescope is operated at f/5 under the same skies, the camera is not background-limited until the integration time exceeds about 1.5 seconds. This implies that without the intensifier, the camera is not operating at the limit of the sky for most operations.

Recent Improvements

In May 1981, I added a Litton Model 841 intensifier to the system. This is a single-stage microchannel plate intensifier with input and output apertures of 18 mm. The unit comes with a self-contained high voltage power supply which requires only 3 VDC from a battery pack in the unit.

Two methods of coupling are commonly used between image intensifiers and TV sensors: relay lenses and fiber optics. While fiber optic connections are a far more efficient method in terms of the amount of light transmitted, they require technology which is currently beyond the budget of an amateur. I used a set of relay lenses to couple the intensifier to the camera head. The complete set-up of the coupling and camera heads is shown in figure 8.

Observations with the intensifier show that the increase in sensitivity is about a factor of 40 for small signals of point sources. Since the intensifier has a nominal gain of about 500, the relay lenses probably cause most of the loss. The relay lenses are composed of a stock eyepiece and an available TV camera objective with a total of seven glass elements, a system which cannot be very efficient. I am currently attempting to design a more efficient relay lens set.

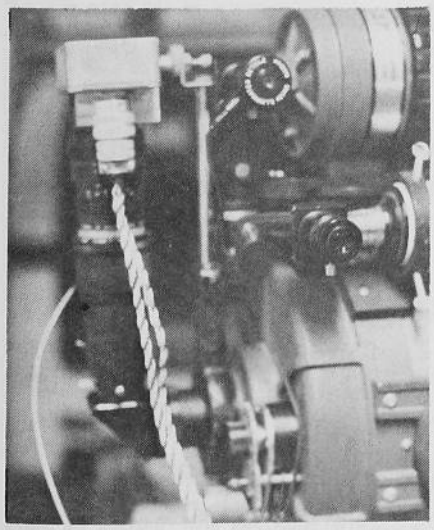


Fig. 8: *The CID camera and intensifier mounted on a C8.*

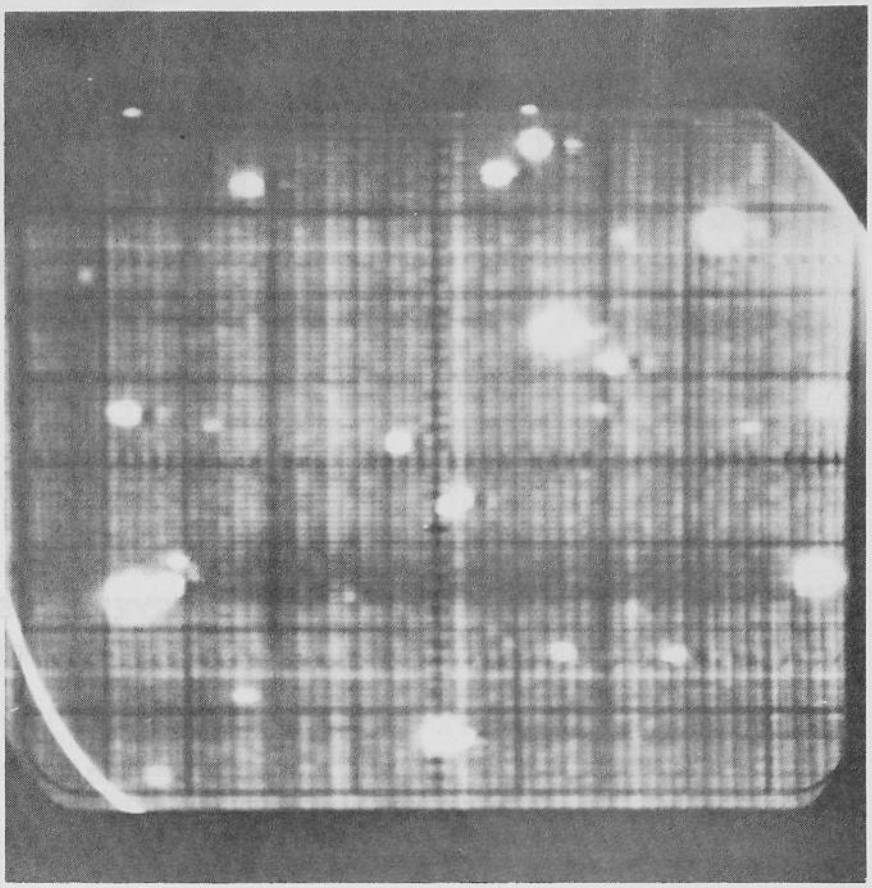


Fig. 9: *The Pleiades on the display oscilloscope screen.*

With the intensifier, the sensitivity of the camera system has improved to the point that stellar photometry and occultation timing has been done with some success. A typical display photographed from the oscilloscope used as a TV monitor is shown in figure 9. The camera was operating at 11 frames per second on the 20.32 cm telescope at f/5. The photo shows the central portion of the Pleiades, including stars to about $m_v = 10$.

In the future, I plan to make several more improvements. I've been working on a digital scan converter for some time. This will take the nonstandard scan rate from the camera and convert it to standard TV rates. The oscilloscope display may then be replaced by a small portable TV. Since the digital scan converter will refresh the conventional TV display no matter what the scan rate of the camera, longer integration times can be used without excessive flicker — effectively increasing the sensitivity of the system.

The scan converter will have three ports: an input port from the camera, an output port to the display, and a bi-directional port to a general-purpose microcomputer. The microcomputer will then be able to process the image or generate track signals to the telescope.

In addition, I'm making a continuing effort to increase the ruggedness and reliability of the system since its most common use is as a field portable camera. The ideas for improvements usually stem from failures or difficulties encountered in the field. While the failure rate has decreased steadily, there are always requests for better controls, cabling, or system packaging.

There are now two cameras of this type operating, one with the San Jose Astronomical Association and one in Arizona. Both, I am certain, will continue to be used for public star parties, astronomical data acquisition, and research into astronomical instruments. The schematics given here should allow amateurs with an electronics background to build a similar system. Any suggestions for improvement are welcome.

Peter Manly
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■

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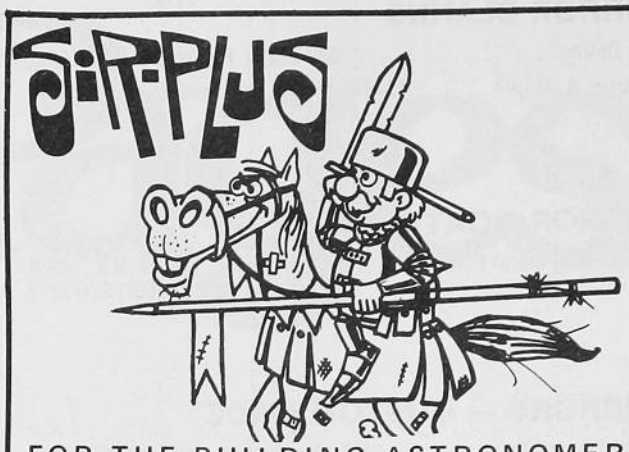

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Letters

◄3

I suspect there are trade-offs on accuracy versus complexity — such a system would have to be compatible with a specific mount, in my case with a German mount, with plus and minus declination and with the scope on either side of the mount.

I believe that some knowledgeable author could put a lot of amateurs on the track of "modernizing" equitorial mounts. Many of us who are well acquainted with mechanics are not familiar with counting and digital readout systems. If we knew what requirements the electronics would impose on the mechanical system, we could go from there.

There is no better place I can think of than TM for taking this lead.

William B. King
20607 6th Ave., SW
Seattle, WA 98166

— Once again, as we have before, we will place your request before the readership. I would like to see something on digital R.A. readouts, too.

Now You Done It!

Good grief, Richard Berry / What have you done! Fred Redburn sends in a nice letter (TM#16) offering to teach us some basic electronics — and you turned him down.

I just spent two days running to the library trying to learn how to interpret a "simple" little schematic diagram showing how to build a blinking reticle for a guide scope because I don't know what all those symbols and lines mean.

We need Fred!

There are all sorts of electronic gizmos that could be added to or modified for use in drive controls, tracking and focusing devices, etc. — let's give him a chance to teach us something. After all, electronics is just as pertinent as articles on programming computers for coordinates and building film sensitization chambers.

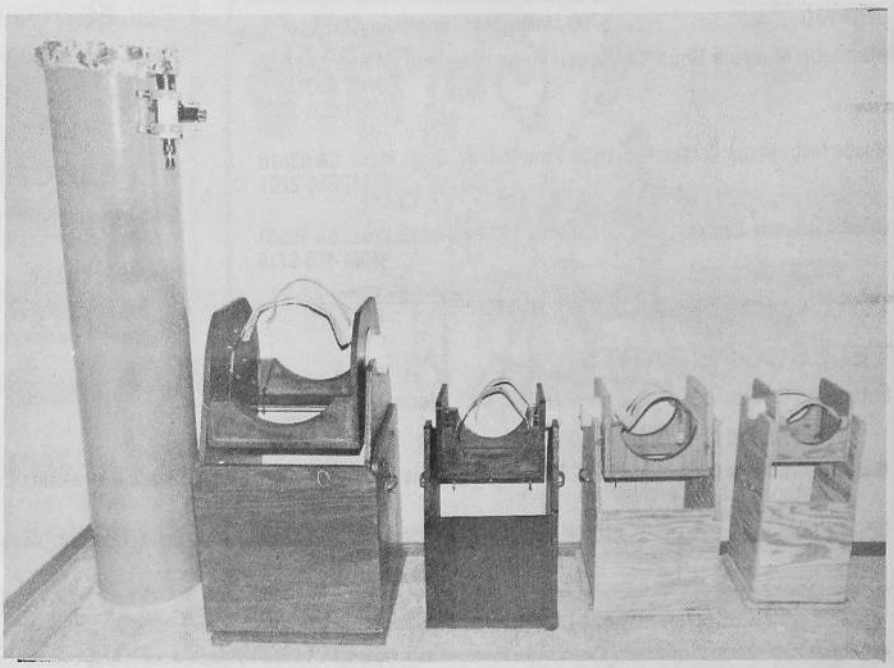
We want Fred!

Howard E. Lazerson, M.D.
8540 So. Sepulveda Blvd.
Suite 1115
Los Angeles, CA 90045

— Give me credit: I did invite reader input. It seems to me that the dividing line lies between electronics for the sake of electronics and TM specific projects that are electronic in nature. If information on the subject were hard to come by, we'd run the article Fred proposed, and happily. But it's not. There are whole magazines devoted to beginner electronics projects. And books. Radio Shack has little pamphlets on electronics — which is how I learned about op amps. Please don't think we're not sympathetic to your needs....

Conversion to Dobsonian

Dear Mr. Berry / I have a commercial 8-inch Newtonian with which I had become fairly proficient at deep-sky photography. When the articles on how to make a Dobsonian first appeared in ASTRONOMY, it got me to thinking. Since 1973 I had been viewing the heavens and taking pictures. The telescope was heavy to lug around and took a while to set up. Also, since I had gotten married during the interim, my opportunities for "all-nighters" had become more limited. Furthermore, I realized that most of my so-called observing time was spent staring at an out-of-focus guide star image!



The Dobsonian mount seemed like a solution to my problems — quick set-up, and I could get back to "observing." I proceeded to build a Dobsonian mount for my 8-inch, but modified the classic design somewhat so the tube could be rotated in the cradle to position the eyepiece for all sizes of observers — since I'm friends with a few school teachers, guess who helps organize and run star parties for the kids!

I used two straps to retain the tube rather than a box around it. This mount works perfectly — it takes less than 8 minutes to carry all the parts out of the house, assemble them and begin observing. I now find I take quick looks at comets, planets, novas, etc., whenever the urge arises.

I have since built a 12.5-inch f/6 reflector using Coulter lightweight optics, a Sonotube that I fiberglassed myself (almost grounds for divorce!) and the same design Dobsonian mount. One problem which I didn't anticipate, but which was easily corrected, was that most of the cradle mass lies below the tube with nothing above to counter-balance. The 12.5" tube weighs 45 lbs and the cradle mount for it weighs 13 lbs. At first the tube could not be primed above 58° in altitude due to the balance problem. To correct the situation, I lowered the closet flanges from the centerline of the tube by an amount that puts equal weight above and below the center point of the closet flanges.

The closet flanges were lowered about 1.25" from their original position. I calculated this by finding the balance point of the cradle (5.5" from the bottom). The centerline of the telescope was 9" from the cradle bottom, subtracting 5.5 from 9, we see a 4.5" difference in the balance points. The ratio of the weights, 13/45, is .289; multiplying this times 4.5", we get 1.3" to move the closet flanges down. The math may not be correct but it worked!

Enclosed are some photos. To date I have made four modified Dobsonian mounts — the 8-inch and 12.5-inch for myself and 8-inch and 6-inch mounts for friends. It really works and is inexpensive. All four mounts have cost a total of $90.00 for materials — and you can't beat that!

Ewell Schirmer
1101 W. Memphis
Broken Arrow, OK 74012

Cats Dead?

Dear Richard / Are you knocking Schmidt-Cassegrainian scopes in your article on Riverside when you say nobody will want to be seen dead with an orange cat? I have one, and I'm willing to be seen alive with it.

Thom Jones
1029 Bull St., Apt. 123
Orange, NJ 08124

— Certainly not. They were the first big design revolution in telescopes, and will probably continue to dominate the commercial market for many decades. Another big company even plans to squeeze into the market in the next year or so — and that should be fun to watch!

Suppose you brought a Pinto to a convention of Model T lovers, and you put it proudly on display. They're both Fords, but wouldn't you feel just a bit, er, out of place, perhaps, standing beside that shiny new car? At amateur telescope making conferences, I've noticed that people do feel that way about mass-produced SCTs, and, sure, they apologize. What I'm asking is: Will that trend continue? In the context of a meeting like the Texas Star Party, where observin' is the whole balla' wax, commercial scope owners just feel right at home.